PUBLICATIONS

OF THE

ASTRONOMICAL SOCIETY

OF THE PACIFIC.

VOLUME III.

1891.

SAN FRANCISCO:
PRINTED FOR THE SOCIETY.
1891.

TABLE OF CONTENTS.*

Publications No. 13, January 1, 1891.

---

* To the Binder: this should precede page 1, Volume III.

Publications No. 16, June 13, 1891.

Publications No. 17, September 5, 1891.

Publications No. 18, October 1, 1891.

Publications No. 19, November 28, 1891.

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

VOL. III. SAN FRANCISCO, CALIFORNIA, JANUARY 1, 1891. NO. 13.

LIST OF MEMBERS

OF THE

ASTRONOMICAL SOCIETY OF THE PACIFIC.

JANUARY 1, 1891.

OFFICERS OF THE SOCIETY.

EDWARD S. HOLDEN (Lick Observatory),	*President*
WM. M. PIERSON (508 California Street, S. F.),	*Vice-Presidents*
FRANK SOULÉ (Students' Observatory, Berkeley),	*Vice-Presidents*
J. H. WYTHE (Oakland),	*Vice-Presidents*
CHAS. BURCKHALTER (Chabot Observatory, Oakland),	*Secretaries*
J. M. SCHAEBERLE (Lick Observatory),	*Secretaries*
E. J. MOLERA (850 Van Ness Avenue, S. F.),	*Treasurer*

Board of Directors—Messrs. ALVORD, BURCKHALTER, GRANT, HILL, HOLDEN, MOLERA, PIERSON, SCHAEBERLE, SOULÉ, WYTHE, ZIEL.

Finance Committee—Messrs. PIERSON, MOLERA, HILL.

Committee on Publication—Messrs. HOLDEN, KEELER, YALE.

Library Committee—Messrs. MOLERA, BURCKHALTER, PIERSON.

Committee on the Comet Medal—Messrs. HOLDEN (*ex-officio*), SCHAEBERLE, BURCKHALTER.

LIST OF MEMBERS.*

JOSEPH S. ADAM,	Canaan, Connecticut.
THEODORE ADAMS,	833 N. Broad Street, Philadelphia, Penn.
CHARLES S. AIKEN,	Berkeley, Cal.
Prof. W. STEADMAN ALDIS,*	*University College, Auckland, New Zealand.*
Hon. HENRY B. ALVORD,*	San José, Cal.
Hon. WILLIAM ALVORD,*	Palace Hotel, S. F., Cal.
Mrs. WILLIAM ALVORD,*	Palace Hotel, S. F., Cal.
T. P. ANDREWS,	333 Kearny Street, S. F., Cal.
Director ANGEL ANGUIANO,	National Observatory, Tacubaya, Mexico.
SETH BABSON,	408 California Street, S. F., Cal.
T. W. BACKHOUSE,	West Hendon House, Sunderland, England.
N. Y. BAILEY,	Early Grove, Mississippi.
CHAS. M. BAKEWELL,	Berkeley, Cal.

* A star signifies Life-Membership. Addresses in italics are not within the Postal Union.

E. E. BARNARD,	Lick Observatory, Mt. Hamilton, Cal
Dr. G. BARROETA,	San Luis Potosi, Mexico.
Hon. JOHN M. BEARD,	Warm Springs, Alameda County, Cal
GEORGE W. BEAVER,	1300 Taylor Street, S. F., Cal.
N. E. BECKWITH,	Los Gatos, Cal.
D. P. BELKNAP,	604 Merchant Street, S. F., Cal.
H. T. BESTOR,	207 O'Farrell Street, S. F., Cal.
Professor FRANK H. BIGELOW,	Nautical Almanac Office, Washington, D. C
E. M. BIXBY,	317 California Street, S. F., Cal.
Hon. JOHN H. BOALT,	332 Haight Street, S.. F, Cal.
Dr. WM. BOERICKE,	834 Sutter Street, S. F., Cal.
JOSÉ A. Y BONILLA,	Plaza del Mercado, 22, Zacatecas Mexico.
J. H. C. BONTÉ, D. D.	Berkeley, Cal.
HENRY LORD BOULTON, JR.,*	Carácas, Venezuela; or Box 2015, New York City.
J. A. BRASHEAR,	Allegheny City, Penn.
Rev. M. S. BRENNAN,	3949 Iowa Street, St. Louis, Mo.
Rev. A. L. BREWER,	San Mateo, Cal.
Miss E. BROWN,	Further Barton, Cirencester, England.
WM. ANDREWS BROWN,	Newton, Mass.
Miss C. W. BRUCE,*	39 E. 23d Street, New York City.
JOHN C. BULLOCK,	1626 12th Street, Oakland, Cal.
CHAS. BURCKHALTER,	Chabot Observatory, Oakland, Cal.
A. J. BURNHAM,	Lick Observatory, Mt. Hamilton, Cal.
S. W. BURNHAM,	Lick Observatory, Mt. Hamilton, Cal.
Dr. J. CALLANDREAU,	1307 Stockton Street, S. F., Cal.
A. CAMERON,	Yarmouth, Nova Scotia.
W. W. CAMPBELL,	Observatory, Ann Arbor, Michigan.
F. J. CASTELHUN,	502 Montgomery Street, S. F., Cal.
J. C. CEBRIAN,	Pine & Octavia Streets, S. F., Cal.
FREDERICK H. CHAPIN,	Hartford, Connecticut.
Rev. C. M. CHARROPPIN, S. J.,	St. Charles, Mo.
Miss MARTHA E. CHASE,	Santa Rosa, Cal.
ISAAC Y. CHUBBUCK,	Roxbury, Mass.
A. R. CHURCH,	1102 10th Street, Oakland, Cal.
Rev. E. BENTLEY CHURCH,	1036 Valencia Street, S. F., Cal.
Principal B. G. CLAPP,	Fulton, New York.
Dr. E. S. CLARK,	16 Geary Street, S. F. Cal.
MATEO CLARK,	27 Queen's Gate, London, England.
C. H. CLEMENT,	Livermore, Cal.
Miss AGNES M. CLERKE,	68 Redcliffe Square, London, England.
H. T. COMPTON,	966 Chester Street, Oakland, Cal.
J. COSTA,	406 Montgomery Street, S. F., Cal.
A. W. CRAIG,	177 8th Street, Oakland, Cal.
HOMER A. CRAIG,	1325 Alice Street, Oakland, Cal.
Hon. C. F. CROCKER,	Leavenworth & Pine Streets, S. F., Cal.
Mrs. M. THORNBURGH-CROPPER,	1023 Ellis Street, S. F., Cal.
Miss S. J. CUNNINGHAM,	Swarthmore College, Delaware Co., Penn.

CHAS. S. CUSHING,	1669 13th Street, Oakland, Cal.
J. EWEN DAVIDSON,*	*Alexandra Plantation, Branscombe, Mackay, Queensland.*
Hon. HORACE DAVIS, LL.D.	1011 Bush Street, S. F., Cal.
Col. E. A. DENICKE,	403 Market Street, S. F., Cal.
A. B. DUPUY,	216 N. 6th Street, Camden, N. J.
Dr. W. A. DEWEY,	834 Sutter Street, S. F., Cal.
Hon. JOSEPH A. DONOHOE,*	Menlo Park, Cal.
W. E. DOWNS,	Eddy, Eddy County, New Mexico.
Mrs. ANNA PALMER DRAPER,*	271 Madison Avenue, New York City.
Dr. L. L. DUNBAR,	500 Sutter Street, S. F., Cal.
HARRY DURBROW,	322 California Street, S. F., Cal.
EARNEST I. DYER,	966 18th Street, Oakland, Cal.
J. RAYNER EDMANDS,	Harvard College Observatory, Cambridge, Mass.
Prof. GEORGE C. EDWARDS,	Berkeley, Cal.
THOMAS GWYN ELGER,	Beaumont House, Shakespeare Road, Bedford, England.
OLIVER EVERETT,	408 California Street, S. F., Cal.
Mrs. MARTHA McC. EWER,	1513 Clay Street, S. F., Cal.
WARREN B. EWER,	1513 Clay Street, S. F., Cal.
Hon. JAMES G. FAIR,*	230 Montgomery Street, S. F., Cal.
H. W. FAUST,	618 Harrison Street, S. F., Cal.
T. W. FENN,	319 California Street, S. F., Cal.
Mrs. J. A. FILLMORE,	Occidental Hotel, S. F., Cal.
Lieut. J. P. FINLAY, U. S. A.,	U. S. Signal Office, S. F., Cal.
W. C. FITZSIMMONS,	Care of J. H. FOUNTAIN & Co., Riverside, Cal.
ANDREW B. FORBES,*	401 California Street, S. F., Cal.
ARTHUR W. FOSTER,*	322 Pine Street, S. F., Cal.
President M. P. FREEMAN,	University of Arizona, Tucson, Ariz.
Prof. CHAS. W. FRIEND,	Observatory, Carson, Nevada.
ROBERT D. FRY,*	1812 Jackson Street, S. F., Cal.
Hon. LEVI K. FULLER,	Brattleboro', Vermont.
JOHN GAMBLE,	Laurel Hall, San Mateo, Cal.
OTTO VON GELDERN,	1513 Vallejo Street, S. F., Cal.
Prof. T. C. GEORGE,	Observatory, College Park, San José, Cal.
LOUIS GEX,	Rua Conde Irajá, No. 20, Rio de Janeiro, Brazil.
General JOHN GIBBON, U. S. A.,	Headquarters Military Division of the Pacific, S. F., Cal.
J. J. GILBERT,	U. S. C. & G. Survey, Box 2512, S. F., Cal.
Dr. DAVID GILL,	*Royal Astronomer, Cape of Good Hope, Africa.*
L. GILSON,	211 Sansome Street, S. F., Cal.
CHAS. GITCHELL,	609 Sacramento Street, S. F., Cal.
Hon. J. M. GITCHELL,	609 Sacramento Street, S. F., Cal.
GEORGE GLEASON,	Berkeley, Cal.
Dr. C. L. GODDARD,	131 Post Street, S. F., Cal.

CAMILO GONZALES,	National Observatory, Tacubaya, Mexico.
Capt. CHARLES GOODALL,*	S. E. cor. McAllister & Pierce Streets, S. F., Cal.
ADAM GRANT,*	N. E. cor. Bush & Sansome Streets. S. F., Cal.
C. MITCHELL GRANT,	331 Kearny Street, S. F., Cal.
JOSEPH D. GRANT,*	N. E. cor. Bush & Sansome Streets, S. F., Cal.
EDMUND GRAY,	838 Alice Street, Oakland, Cal.
ANDREW GREIG,*	Belle Vue, Tayport, Scotland.
C. P. GRIMWOOD,	Fruitvale, Cal.
H. GRATTAN GUINNESS, D. D.,	Bow, London, England.
G. E. HALE,	4545 Drexel Boulevard, Chicago, Ill.
Dr. H. W. HARKNESS,	California Academy of Sciences, S. F., Cal.
Mrs. H. A. HARLAND,	705 Post Street, S. F., Cal.
Prof. M. W. HARRINGTON,	Observatory, Ann Arbor, Michigan.
HENRY HARRISON,	Observatory, South Bergen, New Jersey.
CHARLES F. HART,	The Oaks, North Temescal, Alameda County, Cal.
O. C. HASTINGS,	Box 166, Victoria, B. C.
F. H. HAUSMAN,	328 Montgomery Street, S. F., Cal.
Dr. J. C. HAWVER,	Auburn, Cal.
N. H. HEMIUP,	604 5th Street, S. E., Minneapolis, Minn.
JOHN J. HERR,	438 California Street, S. F., Cal.
WHITNEY HERR,	438 California Street, S. F., Cal.
WM. F. HERRICK,	439 California Street, S. F., Cal.
WILLIAM E. HESS,	519 Kearny Street, S. F., Cal.
A. M. HICKOX,	416 California Street, S. F., Cal.
G. J. HICKS,	31 Clinton Avenue, New Brighton, Staten Island, N. Y.
Prof. ALFRED HIGBIE,	College Park, San José, Cal.
CHAS. B. HILL,	213 Sansome Street, S. F., Cal.
HORACE L. HILL,*	314 California Street, S. F., Cal.
Hon. S. G. HILLBORN,	401 California Street, S. F., Cal.
President A. C. HIRST,	University of the Pacific, College Park, San José, Cal.
GEO. N. HITCHCOCK,	San Diego, Cal.
EDWARD S. HOLDEN,	Lick Observatory, Mt. Hamilton, Cal.
JOHN R. HOOPER,	Howard Nat. Bank, Baltimore, Md.
MAURES HORNER,	Mells, Frome, Somerset, England.
Hon. C. WEBB HOWARD,*	Pacific-Union Club, S. F., Cal.
HUGH HOWELL,	1413 Brush Street, Oakland, Cal.
W. J. HUSSEY,	University of Michigan, Ann Arbor, Michigan.
JAMES E. INGRAHAM,	Sanford, Florida.
WM. IRELAND,	301 California Street, S. F., Cal.
Gen. C. W. IRISH,	Reno, Nevada.
Rev. G. W. JAMES,	Oleander, Fresno Co., Cal.

P. R. JARBOE, ...	168 York Street, New Haven, Conn.
FRANK JAYNES, ...	W. U. Telegraph Co., S. F., Cal.
Miss FIDELIA JEWETT, ...	711 Jones Street, S. F., Cal.
J. H. JOHNSON, ...	10 Market Street, S. F., Cal.
JAMES G. JONES, ...	Room 112, Phelan Building, S. F., Cal.
Hon. JOHN P. JONES,*	Gold Hill, Nevada.
E. B. JORDAN, ...	581 Market Street, S. F., Cal.
Hon. W. H. JORDAN, ...	328 Montgomery Street, S. F., Cal.
HENRY KAHN, ...	642 Market Street, S. F., Cal.
J. E. KEELER, ...	Lick Observatory, Mt. Hamilton, Cal.
Prof. JOSIAH KEEP, ...	Mills College, Alameda County, Cal.
Professor MARTIN KELLOGG, ...	University of California, Berkeley, Cal.
A. E. KENNELLY, ...	Edison Laboratory, Orange, New Jersey.
Miss LAURA KIMBER, ...	Occidental Hotel, S. F., Cal.
Hon. A. KING, ...	Julian Street, San José, Cal.
Prof. D. KIRKWOOD, LL.D.	Arlington Avenue, Riverside, Cal.
Miss DOROTHEA KLUMPKE, ...	National Observatory, Paris, France.
E. B. KNOBEL, ...	Bocking, Braintree, Essex, England.
AUGUSTUS F. KNUDSEN, ...	Box 2139, Boston, Mass.
TORVALD KÖHL,*	Odder, Denmark.
C. F. DE LANDERO, ...	Box 34, Guadalajara, Mexico.
O. V. LANGE, ...	Berkeley, Cal.
Miss LASSELL, ...	Winkton Lodge, Near Ringwood, Hants, England.
JOSEPH G. LAVERY, ...	316 California Street, S. F., Cal.
Prof. JOHN LE CONTE, LL.D. . . .	Berkeley, Cal.
Prof. JOSEPH LE CONTE, LL.D. . .	Berkeley, Cal.
Dr. L. L. LEGGETT, ...	Masonic Temple, Cleveland, Ohio.
Miss MARGARET LEPPER, ...	Box 490, Benicia, Cal.
A. O. LEUSCHNER, ...	University of California, Berkeley, Cal.
Dr. W. B. LEWITT, ...	Hayes & Laguna Streets, S. F., Cal.
THE NEWBERRY LIBRARY, ...	Chicago, Illinois.
Dr. A. LILIENCRANTZ, ...	1459 Telegraph Avenue, Oakland, Cal.
H. C. LION, ...	1534 Mission Street, S. F., Cal.
HENRY B. LOOMIS, ...	Seattle, Washington.
W. H. LOWDEN, ...	213 Sansome Street, S. F., Cal.
Rev. ROBT. MACKENZIE, D. D. . . .	San Francisco, Cal.
J. J. MALOWNEY, ...	Hebron, Nebraska.
Miss L. J. MARTIN, ...	711 Jones Street, S. F., Cal.
Hon. E. B. MASTICK, ...	Office of the Lick Trust, S. F., Cal.
W. H. MAW,*	18 Addison Road, Kensington, London, England.
W. B. MAYES, ...	1127 Lincoln Place, Los Angeles, Cal.
Hon. J. W. MCCLYMANDS, ...	City Hall, Oakland, Cal.
F. H. MCCONNELL, ...	19 Montgomery Street, S. F., Cal.
JAMES JENNINGS MCCOMB, ...	175 W. 58th Street, New York City.
Prof. A. A. MICHELSON, ...	Clark University, Worcester, Mass.
Hon. D. O. MILLS,*	15 Broad Street, New York City.
Hon. ALBERT MILLER,*	532 California Street, S. F., Cal.
E. J. MOLERA, ...	850 Van Ness Avenue, S. F., Cal.

C. F. MONTEALEGRE,	230 California Street, S. F., Cal.
F. G. MONTEALEGRE,	230 California Street, S. F., Cal.
Hon. ALEXANDER MONTGOMERY,*	Leavenworth & Vallejo Streets, S. F., Cal.
Mrs. ALEXANDER MONTGOMERY,*	Leavenworth & Vallejo Streets, S. F., Cal.
W. H. S. MONCK,	16 Earlsfort Terrace, Dublin, Ireland.
C. MOORMAN,	What Cheer, Keokuk County, Iowa.
Prof. IRA MORE,	Normal School, Los Angeles, Cal.
Miss GRACE MORRILL,	706 Taylor Street, S. F., Cal.
Mrs. PAUL MORRILL,	706 Taylor Street, S. F., Cal.
FREMONT MORSE, U. S. C. & G. Survey,	Box 2512, S. F., Cal.
Hon. B. D. MURPHY,*	San José, Cal.
H. F. NEWALL,	Observatory, Cambridge, England.
G. W. NICOLLS,	Banco Nacional, Rio de Janeiro, Brazil.
C. J. NICKERSON,	Oroville, Cal.
P. NOORDHOFF,	Groeningen, Holland.
Hon. WILLIAM NORRIS,	927 Bush St., S. F., Cal.
Miss ROSA O'HALLORAN,	1511 Clay Street, S. F., Cal.
WM. LETTS OLIVER,	1110 12th Street, Oakand, Cal.
WARREN OLNEY,	481 Prospect Avenue, Oakland, Cal.
T. S. PALMER,	Department of Agriculture, Washington, D. C.
Dr. GEORGE C. PARDEE,	526 Montgomery Street, S. F., Cal.
JOHN A. PARKHURST,	Marengo, McHenry Co., Ill.
JOHN PARTRIDGE,	214 California Street, S. F., Cal.
S. C. PARTRIDGE,	226 Bush Street, S. F.. Cal.
Dr. S. C. PASSAVANT,	Care Eastman Manufacturing Company, Rochester, N. Y.
D. PATIN,	1618 Chesnut Street, Philadelphia, Pa.
JAMES N. PEMBERTON,	Downey, Cal.
Professor H. B. PERKINS,	University of Southern California, Los Angeles, Cal.
Hon. GEO. C. PERKINS,*	Oakland, Cal.
C. D. PERRINE,	211 Clay Street, S. F., Cal.
JOHN PERRY, JR.,	Occidental Hotel, S. F., Cal.
ALANSON H. PHELPS,	220 Mission Street, S. F., Cal.
Hon. T. G. PHELPS,	Belmont, Cal.
HENRY PHIPPS, JR.,*	Carnagie, Phipps & Co., Pittsburgh, Penn.
LAWRENCE H. PIERSON,	Pacific P. L. Co., S. F., Cal.
Hon. WM. M. PIERSON,	508 California Street, S. F., Cal.
O. A. L. PIHL,	Christiania, Norway.
CHARLES LANE POOR,	Johns Hopkins University, Baltimore, Md.
THOMAS PRATHER,	Pres't Union Savings Bank, Oakland, Cal.
MANUEL G. PRIETA,	Tacubaya, Mexico.
Prof. H. S. PRITCHETT,	Observatory of Washington University, St. Louis, Mo.
FEODORO QUINTANO,	National Observatory, Tacubaya, Mexico.

A. COWPER RANYARD,*	11 Stone Buildings, Lincoln's Inn, London, England.
ALBERT RAYMOND,	508 California Street, S. F., Cal.
WM. G. RAYMOND,	Berkeley, Cal.
WILLIAM MAXWELL READ,	Harvard College Observatory, Cambridge, Mass.
ALFRED P. REDINGTON,	53 Stevenson Street, S. F., Cal.
GEORGE W. REED,	506 Battery Street, S. F., Cal.
Prof. J. K. REES,	Observatory of Columbia College, New York City.
V. J. A. REY,	829 Union Street, S. F., Cal.
FRANCISCO RODRIGUEZ REY,	National Observatory, Tacubaya, Mexico.
Rev. J. L. RICARD, S. J.,	Santa Clara, Cal.
J. E. RICHARDS,	Los Gatos, Cal.
LESTER L. ROBINSON,*	320 Sansome Street, S. F., Cal.
L. A. ROCKWELL,	Traver, Cal.
Hon. ARTHUR RODGERS,	Nevada Block, S. F., Cal.
F. B. RODOLPH,	969 Washington Street, Oakland, Cal.
A. W. ROSS, JR.,	224 California Street, S. F., Cal.
E. W. RUNYON,	234 Sutter Street, S. F., Cal.
HERBERT SADLER,	32 Manor Street, Clapham, London, England.
G. N. SAEGMULLER,	Care of Fauth & Co., Maryland Avenue, Washington, D. C.
Dr. H. C. SAWYER,	1320 Market Street, S. F., Cal.
Prof. J. M. SCHAEBERLE,	Lick Observatory, Mt. Hamilton, Cal.
RICARDO SCHOTT Y LARIOS,	Malaga, Spain.
HERMAN SCHUSSLER,	Pacific-Union Club, S. F., Cal.
Hon. IRVING M. SCOTT,	507 Harrison Street, S. F., Cal.
JAMES L. SCOTT,	*Care Turnbull, Howie & Co., Shanghai, China.*
Rev. GEORGE M. SEARLE,	Catholic University of America, Brookland, D. C.
Dr. J. M. SELFRIDGE,	Box 37, Oakland, Cal.
GARRETT P. SERVISS,	8 Middagh St., Brooklyn, New York.
Hon. ROBERT SHERWOOD,	303 California Street, S. F., Cal.
J. A. SLADKY,	University of California, Berkeley, Cal.
MELVILLE SMITH,	24 Winthrop Street, Augusta, Me.
WM. F. SMITH,	2426 Pine Street, S. F., Cal.
Prof. F. SOULÉ,	Observatory, Berkeley, Cal.
JOHN R. SPRING,*	328 Montgmery Street, S. F., Cal.
J. W. STATELER,	957 Market Street, S. F., Cal.
President C. C. STRATTON,	Willamette University, Salem, Oregon.
Prof. I. STRINGHAM Ph. D.,	Berkeley, Cal.
Hon. DEMAS STRONG,	71 Broadway, Brooklyn, N. Y.
GEORGE H. STRONG,	220 Market Street, S. F., Cal.
Dr. M. J. SULLIVAN,	30 Post Street, S. F., Cal.
Hon. A. SUTRO,*	74 Montgomery Block, S. F., Cal.
C. F. A. TALBOT,	204 California Street, S. F., Cal.
Dr. J. MUÑOZ TÉBAR,	Carácas, Venezuela, *or* 234 E. 116th Street, New York City.

JOHN TEBBUTT,	*Observatory, Windsor, New Sout Wales.*
WILLIAM THAW, JR.,	Pittsburgh, Penn.
EDWARD J. THOMAS,	234 Montgomery Street, S. F., Cal.
C. W. TIEDEMANN,	312 6th Street, S. F., Cal.
CHARLES R. TISDALE,	Alameda, Cal.
RICHARD M. TOBIN,	Hibernia Bank, S. F., Cal.
FREDERICK C. TORREY,	108 Grant Avenue, S. F., Cal.
Hon. J. W. TOWNER,	Santa Ana, Orange Co., Cal.
A. J. TREAT,	224 McAllister Street, S. F., Cal.
Hon. ALFRED L. TUBBS,*	611 Front Street, S. F., Cal.
W. B. TYLER,	506 Battery Street, S. F., Cal.
FELIPE VALLE,	National Observatroy, Tacubay: Mexico.
M. A. VEEDER, M. D.,	Lyons, New York.
Dr. P. V. VEEDER, D. D.,	614 Sutter Street, S. F., Cal.
RUDOLPH E. VOIGHT,	207 California Street, S. F., Cal.
Rev. JACOB VOORSANGER,	2316 California Street, S. F., Cal.
J. C. L. WADSWORTH,	Pacific Union Club, S. F, Cal.
Prof. J. F. WALLACE,	California College, Highland Parl Oakland, Cal.
W. R. WARNER,	Care of Warner & Swasey, East Pro pect Street, Cleveland, Ohio.
Hon. R. W. WATERMAN,*	San Bernardino, Cal.
FREDERICK G. WATTLES,	15 Winder Street, Detroit, Mich.
R. H. WHITE,	1216 Haight Street, S. F., Cal.
A. STANLEY WILLIAMS,	Percy Lodge, Burgess Hill, Brightor England.
E. C. WINCHELL,	Fresno, Cal.
WILLIAM C. WINLOCK,	Smithsonian Institution, Washing ton, D. C.
G. A. WOOD, M. D.,	Traver, Cal.
Mrs. HARRIET F. WRIGHT,	1111 Corona Street, Denver, Colorad
Rev. J. H. WYTHE, D. D.,	825 14th Street, Oakland, Cal.
CHARLES G. YALE,	220 Market Street, S. F., Cal.
JOHN H. YOELL,	San José, Cal.
EDWARD B. YOUNG,	430 Montgomery Street, S. F., Cal.
FREDERICK W. ZEILE,	202 California Street, S. F., Cal.
F. R. ZIEL,	410 California Street, S. F., Cal.

LIST OF CORRESPONDING OBSERVATORIES AND INSTITUTIONS.

[Arranged Alphabetically by Cities.]

Dudley Observatory, Albany, New York.
Observatory, Algiers, Africa.
Lawrence Observatory, Amherst, Mass.
Detroit Observatory, Ann Arbor, Michigan.
Observatory, Armagh, Ireland.
Library, University of California, Berkeley, Cal.

Redaction Berliner Jahrbuch, Berlin, Germany.
Royal Observatory, Berlin, Germany.
Gesellschaft Urania, Berlin, Germany.
Observatory, Berne, Switzerland.
University Observatory, Bonn, Germany.
Observatory, Bordeaux, France.
Royal Observatory, Uccle, Brussels, Belgium.
University Observatory, Cambridge, England.
Harvard College Observatory, Cambridge, Mass.
Royal Observatory, Capetown, Africa.
Astronomical Society, Chicago, Illinois.
University Observatory, Christiania, Norway.
University Observatory, Cincinnati (Mt. Lookout), Ohio.
Litchfield Observatory, Clinton, New York.
National Observatory, Cordoba, Argentine Republic.
University Observatory, Dorpat, Russia.
Trinity College Observatory, Dublin, Ireland.
Royal Observatory, Edinburgh, Scotland.
Lick College, Fredericksburg, Lebanon Co., Pennsylvania.
Observatory, Geneva, Switzerland.
College Observatory, Georgetown, District of Columbia.
Morrison Observatory, Glasgow, Missouri.
University Observatory, Glasgow, Scotland.
Ducal Observatory, Gotha, Germany.
Royal Observatory, Greenwich, England.
Observatory, Hamburg, Germany.
Shattuck Observatory, Hanover, New Hampshire.
University Observatory, Helsingfors, Russia.
Ducal Observatory, Karlsruhe, Germany.
University Observatory, Kasan, Russia.
University Observatory, Kiel, Germany.
University Observatory, Kœnigsberg, Germany.
Royal Observatory, Kopenhagen, Denmark.
Observatory, La Plata, Argentine Republic.
University Observatory, Leyden, Holland.
Astronomische Gesellschaft, Leipzig, Germany.
University Observatory, Leipzig, Germany.
Royal Observatory, Lisbon, Portugal.
Astronomical Society, Liverpool, England.
British Astronomical Association, London, England.
British Museum, London, England.
Royal Astronomical Society, London, England.
The Nautical Almanac, London, England.
Observatory, Lund, Sweden.
Observatory, Lyons, France.
Washburn Observatory, Madison, Wisconsin.
Observatory, Madras, India.
Royal Observatory, Madrid, Spain.
Observatory, Marseilles, France.
Observatory, Melbourne, Australia.

Stanford University, Menlo Park, California.
Royal Observatory, Milan, Italy.
University Observatory, Moscow, Russia.
Lick Observatory, Mt. Hamilton, California.
Royal Observatory, Munich, Germany.
Royal Observatory, Naples, Italy.
Observatory, Neuchâtel, Switzerland.
Winchester Observatory, New Haven, Connecticut.
Observatory, Nice, France.
Observatory of Carlton College, Northfield, Minnesota.
Chabot Observatory, Oakland, California.
Radcliffe Observatory, Oxford, England.
University Observatory, Oxford, England.
Royal Observatory, Palermo, Italy.
Bureau des Longitudes, Paris, France.
Astronomical Society of France, Paris, France.
National Observatory, Paris, France.
Lord Rosse's Observatory, Parsonstown, Ireland.
Astrophysikalisches Institut, Potsdam, Germany.
University Observatory, Prague, Austro-Hungary.
Halstead Observatory, Princeton, New Jersey.
Imperial Observatory, Pulkowa, Russia.
Observatory, Rio de Janiero, Brazil.
Observatory of the Roman College, Rome, Italy.
Italian Spectroscopic Society, Rome, Italy.
California Academy of Sciences, San Francisco, Cal.
Mercantile Library, San Francisco, Cal.
Mechanics' Institute Library, San Francisco, Cal.
Technical Society of the Pacific Coast, 408 California Street, San Francisco, Cal.
Observatory, Santiago, Chile.
University Observatory, Stockholm, Sweden.
University Observatory, Strassburg, Germany.
Observatory of Sydney, New South Wales.
National Observatory, Tacubaya, Mexico.
University Observatory, Tokio, Japan.
Observatory, Toulouse, France.
University Observatory, Upsala, Sweden.
McCormick Observatory, University of Virginia, Virginia.
Imperial Observatory, Vienna, Austro-Hungary.
The American Ephemeris, Washington, District of Columbia.
Library of Congress, Washington, District of Columbia.
National Academy of Sciences, Washington, District of Columbia.
Naval Observatory, Washington, District of Columbia.
Smithsonian Institution, Washington, District of Columbia.
U. S. Coast and Geodetic Survey, Washington, District of Columbia.
Library U. S. Military Academy, West Point, New York.
Field Observatory, Williamstown, Mass.
Observatory, Zurich, Switzerland.

SATURN, 1879–1889.

EDWARD S. HOLDEN.

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

VOL. III. SAN FRANCISCO, CALIFORNIA, JANUARY 31, 1891. NO. 14.

OBSERVATIONS AND DRAWINGS OF *SATURN*, 1879–1889.*

BY EDWARD S. HOLDEN.

During the years 1879–1890, I have made many observations of *Saturn* with the 26-inch equatorial at Washington (1879–80), the 15½-inch at the Washington Observatory (1881–85) and with the 36-inch at the Lick Observatory (1888–90).

For the purpose of recording my notes graphically, I had a set of blank forms engraved on wood, so that the set of six forms would represent (approximately) every degree of inclination of *Saturn's* ring. Each of the accompanying sketches is made on one of these forms; and some distortion of the true figure is introduced in this way. Only that part of each sketch was finished which seemed to have some special significance at the time of observation. The drawings were not intended to be completed pictures, but graphic notes to accompany the written memoranda herewith.

The scale of shading has not been kept constant throughout the eleven years. Two surfaces, equally dark in the accompanying sketches, might have been of quite different brightness when seen on the planet. In the blank forms the engraver inserted some bounding lines, which should have been omitted. Where these are especially misleading I have inserted an *x* in the foregoing sketches. In spite of these various faults, I have thought that the sketches, and particularly the notes of observation, might be worthy of publication, and I beg to present them to the Society. The planet has been observed on very many occasions of which there is no note here, without seeing any feature calling for special remark.

* See frontispiece. The Lithographer has been unable to copy my original drawings and I have changed them somewhat by retouching, making them far less satisfactory to myself in the process.

The observations were all made with unusually powerful telescopes. A particular feature in regard to the series is that the sketches do *not* show certain peculiarities of *Saturn*, which have been reported by other observers with smaller telescopes. This may be due to a failure on my own part, but I am inclined to think that it is sometimes, at least, due to the fact that the phenomena of the very complex system of *Saturn* are often too difficult for small instruments. A feature which, by its small size, or by its faintness, is at or near the limit of vision for a small telescope, can often be seen with perfect precision in a larger one. The shortcomings in the present notes cannot, at any rate, be attributed to the instruments employed, since they have all been proved to be of first-class excellence.

Nomenclature.

The drawings are arranged so that the N. pole of *Saturn* is towards the bottom of the figure, and the W. end of the ring is towards the left hand. The outer ring is called A, the main ring B, the dusky ring C. The principal division between A and B is the CASSINI division. The division in ring A (before 1888) is the ENCKE division. No division was seen between rings B and C during these observations.

The steadiness of the atmosphere is noted on a scale of 5 = perfectly steady, 3 = average, 1 = extremely unsteady. Notes added in copying for publication have been put in brackets [ ].

Notes of Observations of Saturn.

1879, Sept. 24, 12^h W. m. t. 26-inch equatorial. Wt. 2.

(*See* Figure 1.) The CASSINI division can be traced no further than it is drawn in the figure. The shadow of the ball on the ring is not black, but ashy-grey; it is not more than $0''.5$ wide at its north end, nor more than $1''.5$ at its south end, and it appears convex to the ball.

1879, Sept. 29. About 11^h W. m. t. 26-inch equatorial. Wt. 4.

(*See* Figure 2). The CASSINI division is as drawn. The division in Ring A is seen at the west end only. Ring B consists of two main parts; the outer part is bright, the inner is grey and much fainter.

1879, Oct. 11, 12^h 15^m W. m. t. 26-inch equatorial. Wt. 5.

(*See* Figure 3). The original drawing is a sketch of the shadows only. Nothing is said about the CASSINI division in front of the ball. Shadows of the ball on the ring are visible on both sides of *Saturn*.

On the west side the shadow is the thinnest possible line as far as the principal division. On both sides the shadow consists of two parts, bounded by nearly straight lines, which meet at an angle as shown. The CASSINI division is seen quite up to the shadows on both sides.

1879, Oct. 16, about 12^h 30^m, W. m. t. 26-inch equatorial. Wt. 2.

(*See* Figure 4.) [To economize space, Figures 3 and 4 are drawn on the same form in the frontispiece. 4 refers to the N. part of the figure only.] The shadow of the ball on the rings is seen on both sides. [No drawing made of this.] The shadow of the ring on the ball is the thinnest possible line, as drawn, thickened at the ends. It looks perfectly straight.

1879, Nov. 3, 12^h W. m. t. 26-inch equatorial. Wt. 2—Eyepiece, 600.

(*See* Figure 5.) *Ball:* the Southern Hemisphere is nearly all an olive-green and dark. All the rest is bright, and no markings are seen, except one streak in the Northern Hemisphere, as in the sketch.

Rings: They are as usual and as drawn.

Shadow of Ball on the Ring: Convex towards the ball [as is usual when the air is not steady] and broken at the principal division. This division, however, is not seen any further than as drawn.

Shadow of Rings on the Ball. Very dark, and the ends widened, as in the figure.

Dusky Ring: The ends of the dusky ring as seen on the ball at the limbs of the planet [above the rings in the figure] are widened, so that the ends on the planet appear broader (north and south) than the fine ends of the dusky ring [outside the ball] which come up to the limbs and meet them.

The whole dusky ring is not so well seen to-night as before, and it appears really fainter.

1879, Nov. 11, 10^h W. m. t. 26-inch equatorial. Wt. 2. Sky hazy.

(*See* Figure 6.) There appears to be a dark patch on the east side of the South Pole, and, possibly, one near to the North Pole, much fainter. The shadow of the ring on the ball is as drawn. The principal division is not seen beyond the points marked.

1880, Aug. 21, 12^h 45^m to 13^h 20^m, W. m. t. 26-inch equatorial, eyepiece 400, Wt. 3. Sky very hazy.

(Drawing omitted.) The shadow of the ball on the ring is not so black as the spaces within the ansae. The curve of the edge of this shadow appears to be very slightly convex to the ball. The principal division is seen all around. ENCKE'S division in Ring A is seen near the ends of the ring.

1880, Aug. 24. 26-inch equatorial, eyepiece 400. Wt. 4.

(*See* Figure 7.) The principal division is seen all around. The ENCKE'S division is as drawn. It divides Ring A into two parts, whose widths are as 1 to 2, and it is nearer the outer ellipse of Ring A. The south hemisphere of the ball is a warm olive color. The edge of the shadow of the ball on the ring is nearly a straight line, but it is a very little convex to the ball, and it is *black.*

The shadow of the ball on the ring is 2½ times wider at its S. edge than at the N.

The grey shading in Ring B extends from the outer ellipse of the dusky ring to ⅔ of the way to the CASSINI division.

The ends of the dusky ring on the ball [above the rings in the figure] make a little angle where they meet the ends of this ring outside the ball [*i. e.*, the ends on the planet are wider.]

1880, Aug. 26. Time? 26-inch equatorial.

(Drawings omitted.) The shadow of the ball on the ring has about these proportions: west side 3, south side 3, north side 1.

1880, Aug. 27. 26-inch equatorial, Eye-piece 800. Wt. 5. (Drawing omitted.)

The shadow of the ball on the ring is, on the whole, slightly concave to the ball. The appearance of concavity arises from a break in the outline of the shadow at the principal division. The shadow of the ball is seen *on the dusky ring*, and leaves a little sharp corner where this shadow meets the inner ellipse of the dusky ring. The outlines of the principal division are smooth all around. There are no notches at the ends, as drawn by M. TROUVELOT in 1874. There is a trace, and only a trace, of ENCKE'S division on Ring A, ⅓ of the distance from the outer to the inner ellipse of the ring.

Ring B appears to be composed of three rings, distinguished by the difference of shading. The inner one of the three is ⅓ the width of Ring B; the two inner ones together are about $\frac{6}{10}$ of this width.

The ends of the dusky ring at the limbs of the planet are wider (north and south) at the limbs than the fine ends of the dusky ring outside the ball which come up to meet them. [This has been previously noted, and *may* be due to the presence of a narrow, dark belt on the planet itself, which is not seen separate from the dusky ring crossing the ball.] At the ends of the dusky rings on the ball there is a distinct "step" at the limb.

It is certain that the outline of the ball cannot be seen through the dusky ring on the west side, but I am almost sure that I see it on the east side.

1880, Sept. 2. 12^h W. m. t. 26-inch equatorial, Eye-piece 400.

(*See* Figure 8.) The sketch is not accurate as to all its dimensions, but it gives the relative shapes and general effect correctly.

1880, Oct. 8. 13^h W. m. t. 26-inch equatorial. Wt. 3. (Drawing omitted.) Sky not perfectly clear.

The principal division is seen up to within about 4″ of the ball, both in front of and behind the planet. The shadow of the ball on the ring on the west side of the planet is bounded by two straight lines, *a* and *b*. *a* is parallel to a tangent to the S. W. quadrant of the outline of the ball near latitude 45°. *b* makes an angle of 55°–60° with the circumference of the ball near it. *a* and *b* meet at a vertex at the principal division. There is a shade on the ball which borders the shadow of the ball on the west end of the ring. There is also a faint beginning of a shadow of the ball on the ring on the east end of the ring.

1880, Oct. 9. 26-inch equatorial, Eye-piece 800.

(*See* Figure 9.) The shadow of the ball on the ring is seen on both sides of the ball. On the west side, the bounding line of the shadow is a perfectly straight line, and the outer edge of the ring ends in a *fine*, sharp, cusp point; the effect is, perhaps, as if this boundary was slightly, but very slightly, concave to the ball. On the east side of the ball there is a straight, dark, narrow line of shadow also. The CASSINI division is seen all around. The ENCKE division is *well* seen ⅜ of the width of Ring A from its outer edge.

1880, Oct. 10. 26-inch equatorial, Eye-piece 800, Wt. 4.

(*See* Figure 10.) The southern hemisphere of the ball is olive-color. There are two shades or blurs on the ball bordering the shadows of the ball on the ring (which are on both sides).

The shadow of the ball on the ring on the west side is 0″.23 thick at its north end, and 0″.35 at its south end. The shadow of the ball on the ring east of the ball is 0″.23 thick. The dusky ring is suddenly wider as it crosses the ball. The principal division is perfectly smooth all around [no notches in it.] ENCKE's division is seen ⅜ of the width of Ring A from its outer ellipse.

1880, Oct. 11. 26-inch equatorial, Eye-piece 600, Wt. 5.

(*See* Figure 11.) The shadow of the ball on the ring on the west side is *very* narrow at its north end, and a very little wider at its south end. The bounding line is nearly straight, but just perceptibly concave to the ball. The shadow of the ball on the east side is narrower than that on the west, and it appears very slightly convex to the ball. The shadow of the ball on the dusky ring is seen on the east side [only.] I cannot see the limb of the planet through the dusky ring. The principal division is seen up to the shadows on both sides. The dusky ring is suddenly wider as it crosses the ball.

1880, Oct. 12. 26-inch equatorial.

The seeing is too poor for drawing or measures. To-night the shadow of the ball on the ring on the east side looks *very* convex to the ball, while on the preceding side it is considerably concave.

1880, Oct. 15. 26-inch equatorial.

(*See* Figure 12.) Near A and B on the ball are two bright areas. Between them it is darker. Below this dark area it is brighter again. Near the South Pole is a dark olive zone (not so dark as Oct. 11.) The bright knots near A and B are whitish yellow. Just above the equatorial belt the bright space described is less yellow and more inclining to rose-color. The equatorial belt is the brightest part of the ball, and is full of rose-tints. The areas near A and B, and the black shadows just outside them, give to the limb of the ball the straight-line appearance shown in the figure. This phenomenon, which was carefully studied at the telescope, appears to be related to the "square-shouldered" figure of *Saturn* remarked by W. HERSCHEL, in 1805. The south polar cap helps this effect.

1880, Oct. 18. 26-inch equatorial, eyepiece 400, Wt. 2.

(Drawing omitted.) There is hardly any shadow of the ball on the ring on the west side of the planet, if, indeed, there is any. The shadow of the ball on the east side of the ring appears slightly, though certainly convex to the ball. It is quite narrow. The zone of the ball near the South Pole is dark. The central belt is rosy red.

1880, Nov. 7. 26-inch equatorial, eyepiece 400, Wt. 3.

(*See* Figure 13.) The shadow of the ring on the ball, Nov. 7, is north of the ring. The distance between the S. edge of this shadow and the principal division in front of the ball is not more than $0''.3$, and yet I see the white line separating them all the time. I even seem to see the principal division here in front of ball better than usual. The dusky ring on the ball is *much* lighter than the shadow of the ring on the ball. The shadow of ball on ring in the drawing is 1¼ times as wide (east and west) as it should be. The shape is right. Just north of the S. polar dark belt, and at the limb, are two white areas, such as I saw Oct. 15. They produce now something like the square-shouldered aspect, especially on the preceding side, but not so marked as on Oct. 15.

1881, Jan. 12. 26-inch equatorial, eyepieces 400 and 600, *observer* Professor A. HALL.

(*See* Figure 14.) "Division of the ring is sharp and clean. Belts on the ball are very faint. Strong moonlight."

1881, July 29. 15½-inch equatorial of the Washburn Observatory, eyepiece 145. (*See* Figure 15).

1881, Nov. 27, 8^h 30^m Chicago m. t. 15½-inch equatorial, eyepieces 300, 400. Definition is steady. Moonlight.

(*See* Figure 16).

The width of the dusky ring is half of the distance of the ball to the inner edge of Ring B. The shaded part of B is ⅔ of the width of B. There is a notch in the shadow of the ball on the ring, just at the principal division. The division in Ring A at ⅓ of its width from the outer ellipse, is suspected for over an hour. It is plainer at the preceding end; but I am not absolutely sure of it, after all.

1881, Dec. 7. 15½-inch equatorial, powers 260, 430. Sky hazy.

(Drawing omitted.) The seeing is very steady, through a light haze. The division in Ring A is suspected, as before (Nov. 27), but it is not perfectly certain. The notched shadow of the ball on the ring is certain. The ends of the shadow of the ring on the north hemisphere of the ball are plainly much wider than the middle of this shadow. Both ends are now equally wide, whereas, on Nov. 27, the *east* end appeared to be the wider. The markings on the ball appeared in general as they were on Nov. 27, but the whole sky became cloudy before a drawing could be made or measurements begun.

1882, Sept. 25, 15^h 30^m, Chicago m. t. 15½-inch equatorial. The seeing is good.

(*See* Figure 17.) On the east side of the planet the outer ellipse of the outer ring prolonged towards the west seems almost exactly tangent to the south limb of the ball. On the west side, on the contrary, the ring seems to be moved upwards (south) so that the principal division (prolonged) is almost tangent to the ball, and the outer ellipse of the ring (prolonged) seems to pass to the south of the ball. The illusion continues even where the principal division alone is regarded.

On the east side the principal division (prolonged) plainly intersects the ball. On the west side, however, it is *almost* tangent to it.

A kind of reason for this can be given. On the east side the outer ellipse of Ring *A* comes close to the ball with no black division in between them. It, therefore, seems tangent to it. On the W. side first comes the south limb of the ball, then the shadow of the ball on the ring and beyond and south of this is the Ring A. A very little change in the correct appreciation of the angle terminating the shadow will alter the position of the end of the Ring A greatly. The illusion in regard to the prolongation of the principal division I explain by supposing the eye makes *this* ellipse to be similar to that of the outer ellipse of Ring A, and does not takes its true shape as a guide.

1882, Oct. 3. 15½-inch equatorial, Eye-piece 145.

(*See* Figure 17 *a*.) The general shape of the shadow of the ball on the ring is as drawn, only I have exaggerated the dimensions in order to show the true form more clearly. The south limbs of the ball and of the ring are about tangent. None of the ball is visible north of the ring.

1882, Nov. 8. 15½-inch equatorial, Eye-pieces 145, 240. Wt. 5.

(*See* Figure 18.) The north pole of the ball is just barely visible north of the ring. The principal division is seen all around. The night is very fine. The ENCKE division in Ring A is well seen on the west side as far as the end of the major axis of the dusky ring (outer ellipse.) It is not so well seen on the east side. It divides Ring A into two parts as 2 to 3. [It is, therefore, ⅖ of the way from the outer ellipse of Ring A towards the inner one.] The southern hemisphere of the ball is dark; the region near the south pole is the darkest. There is a dark stripe along the south edge of the bright equatorial belt, and this belt has a narrow stripe along its middle. The shadow of the ball on the ring is seen on both sides of the ball, and the shape is the same on both sides, but the shadow on the west is darker than that on the east.

1883, Nov. 24. 15½-inch equatorial, Eye-piece 145.

(*See* Figure 19.) The ENCKE division is not seen. The CASSINI division is seen all around. The drawing is made to show the shape of the shadow of the ball on the rings. The principal division forms a part of this, and the south limb of the ball of the planet looks like a straight line.

1883, Dec. 2. 15½-inch equatorial, Eye-piece 195.

(*See* Figure 20.) The CASSINI division is seen all around. The ENCKE division is seen at both ends of the ring. The shadow of the ball of the ring is as drawn. It is wider and of a different shape at the west end, as drawn. I did not specially look for (nor see) the shadow of the ball on the Ring C. The south polar region of the ball of the planet is mottled, especially near the shadows. The bright equatorial belt is bounded on the south by a narrow, dark streak some 2″ wide. This is the darkest marking on the ball. South of this is an equally narrow, bright streak, and south of this again is the nearly uniform southern hemisphere. North of the equatorial bright belt is a narrow, dusky belt (1½″ ?), then a narrow, bright belt (1½″ ?), and then a dark band, which is the dusky ring itself (Ring C).

1888, Nov. 5. 36-inch equatorial, Eye-piece 600. Observers, J. M. SCHAEBERLE and E. S. HOLDEN.

(Drawing omitted.) The southern hemisphere is olive-green.

[The south polar region itself is the same color over a region about 0″.5 (north and south) by 2″.2 (east and west). This region is enclosed by a narrow, dark belt (first discovered by J. M. S. , which is a little less than 1″ in width.]

1889, March 22, 8^h 30^m P. s. t. 36-inch equatorial, Eye-piece 2000, Wt. 5. Slight haze. Observers J. M. S. and E. S. H.

(*See* Figure 21.) KEELER's division is seen. J. M. S. sees a new division in Ring B, as drawn. [It was estimated as ¼ of the width of Ring B from its inner ellipse, but the sketch made does not agree with this. The existence of this division has never been confirmed].

Beside the foregoing unpublished observations, the following publications relating to the appearance of the planet have been made by one or more of the astronomers of the Lick Observatory:

Saturn and his Satellites, *Sidereal Messenger* for January, 1889.

Reported Changes in the Rings of Saturn, *Astronomical Journal*, vol. 8, page 180.

The Square-shouldered Aspect of Saturn, *Publications* A. S. P., July 12, 1890.

First Observations of Saturn with the 36-inch Equatorial, *Sidereal Messenger*, 1888, page 79.

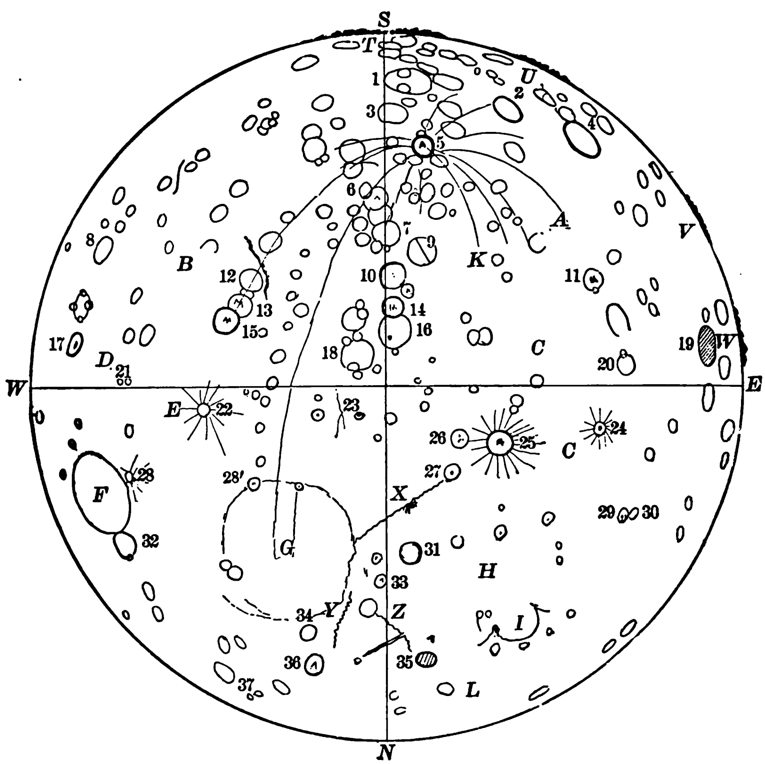
The Appearance of Saturn in the 36-inch Telescope, *Ciel et Terre*, January, 1889, page 514.

The Outer Ring of Saturn, *Ciel et Terre*, April, 1889.

INDEX-MAP OF THE MOON.*

[By Professor Charles A. Young, Director of the Halstead Observatory, Princeton, N. J.]

"The accompanying figure is reduced from a skeleton map of the moon, by Neison, and though not large enough to exhibit much detail, will enable a student, with a small telescope, to identify the principal objects by the help of the key."



KEY TO THE PRINCIPAL OBJECTS INDICATED ON THE INDEX-MAP.

A. Mare Humorum,	E. Mare Tranquilitatis,
B. Mare Nectaris,	F. Mare Crisium,
C. Oceanus Procellarum,	G. Mare Serenitatis,
D. Mare Fecunditatis,	H. Mare Imbrium,

* We owe to the kind permission of Professor Young, and of his publishers, the right to reprint the following from his Elements of Astronomy, 1890.

I. Sinus Iridum,
K. Mare Nubium,
L. Mare Frigoris,
T. Leibnitz Mountains,
U. Doerfel Mountains,
V. Rook Mountains,
W. D'Alembert Mountains,
X. Apennines,
Y. Caucasus,
Z. Alps.

THE PRINCIPAL LUNAR CRATERS.

1. Clavius,	14. Alphonsus,	27. Erathosthenes,
2. Schiller,	15. Theopilus,	28. Proclus,
3. Maginus,	16. Ptolemy,	28'. Pliny,
4. Schickard,	17. Langrenus,	29. Aristarchus,
5. Tycho,	18. Hipparchus,	30. Herodotus,
6. Walther,	19. Grimaldi,	31. Archimides,
7. Purbach,	20. Flamsteed,	32. Cleomedes,
8. Petavius,	21. Messier,	33. Aristillus,
9. "The Railway,"	22. Maskelyne,	34. Eudoxus,
10. Arzachel,	23. Triesnecker,	35. Plato,
11. Gassendi,	24. Kepler,	36. Aristotle,
12. Catherina,	25. Copernicus,	37. Endymion.
13. Cyrillus,	26. Stadius.	

THE OBSERVATORY OF SWARTHMORE COLLEGE.

By Miss Susan J. Cunningham, Director.

In consequence of a growing need felt in the teaching of Astronomy here at Swarthmore College, for some suitable apparatus for

illustrating the methods of finding Latitude, Time, etc., it was determined, about five years ago, to make an effort to secure a small observatory equipped with instruments for teaching purposes. It was thought that, perhaps, a sum of $2000 would cover the cost of the necessary apparatus, and suitably house it; in consequence of this, a committee from the Board of Managers of the College was appointed to see what might be done in the way of obtaining subscriptions to the enterprise. The result was that a sum of about

$7000 was obtained, with which a neat building was constructed of wood, containing a central dome, in which is placed the equatorial telescope; and the two wings, one for the transit instrument and mean-time clock, and the other for a work-room. The latter has been suitably warmed from the professor's house adjoining; in this room the nucleus of a library is placed with the batteries, chronograph and chronometer. On the ground floor of the central building is placed the sidereal clock.

In the dome stands a six-inch refractor, with object-glass by ALVAN CLARK & SONS, and mounting by WARNER & SWASEY; it is provided with clock-work, and an attachment for the electrical illumination of the circles and micrometer. There are five eye-pieces, varying in power from 75 to 500, a large eye-piece for the moon, and a diagonal eye-piece for both sun and stars, and also a micrometer. There is also a very fine spectroscope, with a ROWLAND grating, constructed by BRASHEAR, but no photographic apparatus.

The transit instrument with 3½-inch object-glass is also of WARNER & SWASEY'S mounting, and stands upon a foundation of solid mason work of about twelve feet in depth; it is provided with two large finding circles, one roughly graduated, and the other graduated upon silver to 10″ of arc, and carrying two verniers, a striding level, and also a level attached to the horizontal axis of the telescope; to the eye-piece is attached a micrometer, capable of being turned one-quarter around, in order that, with the second level, the instrument may be used as a zenith telescope, as well as a transit instrument. The chronograph is also of WARNER & SWASEY'S make, and can be connected with either clock. A barometer, wet and dry bulb thermometers, also a maximum and minimum thermometer, made by H. J. GREEN, of New York, were added about two years ago, and observations are recorded three times daily, in connection with the Pennsylvania State Weather Service (the observatory being a volunteer station.) A rain-gauge and anemometer, with registering clock, are also among the meteorological outfit, and during the present year a DRAPER'S self-registering thermometer has been added. The U. S. Signal Service weather flags are displayed daily, according to the data announced by the service, and a weather map is received and placed on view each day.

As yet the observatory, according to its original design, has been used for teaching purposes only, and for the pleasure of visitors, but it is hoped that, in time, astronomical work may be done here.

AN ACCOUNT OF AN EXPERIMENT MADE TO DETERMINE WHETHER GRAVITATION FORCE VARIES WITH TEMPERATURE.

By A. E. Kennelly, Edison Physical Laboratory, Orange, New Jersey.

Result. *Negative.* No change was detected in the weight of a platinum wire between the temperatures of 20°C., and bright red heat, say 800°C., the limit of certain detection being 0.35 %, or one part in 300.

So far as our present limited knowledge of gravitation extends, this force varies only with the distance of the material particles considered, and is independent of every other condition of matter, space or time. This singular degree of constancy, so remote from the conditions in which we find other physical forces, suggests either a discrepancy in our data, or a lack of evidence bearing upon this vast subject, whose very cause is still so obscure.

The experiment of weighing a body, at different temperatures, to ascertain if any variation in weight takes place depending upon thermal conditions, has probably been repeated more than once since the days of the Phlogiston controversy, and of Voltaire. The absence, however, of general information in text-books upon the limit to which any such research has been carried, prompted the experiments about to be detailed, whose result, although negative, may either save others the time necessary to ask Nature the same question, or induce them to seek their answer within a closer degree of accuracy than that here stated.

An incandescent electric lamp was placed on the pan of a delicate chemical balance, and its terminals placed in communication with a dynamo by means of a pair of fine copper wires, just heavy enough to carry the lamp current without fusing, and dipping vertically into mercury cups suitably placed beside the pan. This arrangement, of course, materially reduced the sensibility of the balance, not only on account of the mechanical damping of vibration, and the weight of the copper wires varying with the depth of mercury immersion, but also on account of the capillary force brought into play at the contact surfaces. By carefully observing the extremity of the pointer through a lens, however, a very fair degree of accuracy could be attained. The lamp was first balanced at the normal temperature, and then, with the balance true, the electric current was forced through it, bringing it to incandescence. The connections and wires were easy to arrange in such a manner that the vertical component of the electro-magnetic forces brought into play would be insignificantly small, except the repulsion between the fine copper electrodes and the mercury into which they dipped, an influence that did not seem to be capable of elimination, and whose effects upon the observations could fortunately be differentiated and allowed for.

The first lamp tried was an Edison bamboo carbon lamp of special construction, having a comparatively heavy and spiral filament in ten spires 0.75 cm. in diameter, the filament itself being of rectangular cross-section 0.028 $\times$ 0.048 cm., or 0.00133 sq. cm. area. The length of the filament was about 30 cms., its surface 4.5 sq. cms., and its weight 0.0405 gramme.

The weight of lamp and connecting wires together, (with an inverted glass beaker placed over all as a cover to check convection air currents) was 124 grammes, and with this load the balance readily indicated to $\frac{1}{10}$ of one milligramme, the arms being 22 cm. long, the pointer 30.5, and the period of one double vibration 40 seconds. The immersion of the fine copper electrodes in the cups reduced the limit of appreciation to $\pm$ 2 milligrammes, and the period of double vibration to 3 seconds. The electrical pressure brought to bear upon the lamp was 120 volts, the current being almost 2 amperes. This brought the lamp to vivid incandescence within one second. The duration of current application varied in different trials between 5 and 30 seconds. No change was ever noticed within five seconds of closing the lamp circuit. After that time a slight indication of lessening weight in the lamp pan would show itself, increasing steadily with the duration of current flow. In most cases this apparent loss of weight tended to a maximum (equivalent to about 15 milligrammes), some 150 seconds after the current was cut off, when the effect slowly diminished, and a tendency to restore the original balance set in. This behavior, coupled with the fact that no change in the above order of events could be detected with the current through the lamp in the opposite direction, pointed to convection as the source of variation. Under the circumstances, a change in weight due to any effect in temperature upon the weight of filament, would have been detected probably to the extent of $\pm$ 2 milligrammes, and almost certainly had it amounted to $\pm$ 3 mgms. The experiment was, however, very inconclusive, since the total weight of filament being 40.5 mgms., the limit of certain detection was only 7.5 % of all, and carbon, owing to its lightness, is a material really unsuited for the experiment.

A special platinum wire incandescent lamp was then tried. This wire was 51.3 cms. long, 0.032 cm. in diameter, and was coiled into a helix of 18 spires. Its weight was 863 milligrammes. The glass globe, connections and general arrangements were all similar to those preceding. The lamp and beaker were balanced by 131.3 grammes. The fine copper electrodes were 0.0065 cm. in diameter, and were separated by a distance of 0.5 cm. With careful immersion in the mercury tubes, the limit of appreciation of balance was ± 1 mgm. The current forced through the lamp was slowly increased in successive trials from 1.5 to 2.9 amperes, which raised it to bright redness. It was found impracticable to raise the temperature beyond this stage, since the rigidity of the platinum threatened to depart, rendering collapse of the heavy spiral imminent. The results obtained in this case are, therefore, limited to the stage of temperature corresponding to bright redness, assumed, in the absence of more precise knowledge, to be about 800°C.

On closing the lamp circuit a change representing loss of weight in the lamp pan would generally be detected within two seconds. This appeared to remain stationary a few seconds longer, (at about 1 mgm. equivalent), and then a further steady diminution set in, progressing with the duration of current application, and generally finding a maximum (equivalent to 10 or 20 mgms.), after the current's cessation. The duration of the flow varied from 10 to 40 seconds. With the lower strength of current first adopted, 10 seconds was required to bring the platinum wire to red heat, while, in the latter trials, the stronger currents produced visible red heat in four seconds. The facts that:—

(1.) No change of weight was observed coincidently with the rise or fall of temperature in the wire,

(2.) The change of weight apparent took place before any high degree of temperature was attained, and lingered long after the reduction of that temperature,

(3.) The absence of any apparent relation between these phenomena and the direction of current in the wire,

all suggested that the belief that the changes in balance observed were due in the first stage to a steady electro-magnetic repulsion between mercury cups and the immersed electrodes, and, in the later stage, to the expansion of air round the lamp by heat generated within it.

The limit of probable detection in the weight of the lamp would have been ± 1 mgm., while a change of ± 3 mgms. would hardly have escaped observation, a percentage of 0.35, or nearly one part in 300.

It would, of course, be quite possible to reduce considerably this outstanding limit of uncertainty, by making the necessary weight in the lamp wire, and with increased care in mounting the same.

Appendix. The electro-magnetic repulsion acting in these experiments can be approximately computed from a formula due to CLERK-MAXWELL.

$$f = 2c^2 \log_e \left(\frac{d}{r}\right)$$

where f is the force of repulsion in dynes, c is the current flowing through the circuit in absolute measure, d is the distance separating the axes of the wires, in cms., and r is the radius of the wires in cms.

In this case c is 2.9 amperes, or 0.29 units, d is 0.5 and r is 0.0033. Whence f is 0.84 dyne, equivalent to 0.86 milligramme weight, or of the same order as the first effect noticed.

EDISON LABORATORY, ORANGE, N. J., 29th Oct., 1890.

CORONAL EXTENSION.

BY C. M. CHARROPPIN, S. J.*

The most distant stretch of the streamers of future eclipses, in all probability, will never be recorded on a sensitive plate; because, since the coronal rays diminish in brightness as they recede from the sun, a limit must be reached, when the faintest beams will be of equal brightness with the illuminated air: then, and only then, will they fail to impress themselves on the photographic plate: for the haloid salts of silver deal only with lights and shadows. They will delineate the most delicate pencils of light: they will record the very line where the faintest ray is immersed in the tiniest shadow: but when contrast ceases to exist, they at once become dumb. The faintest beam of nebulous matter, which the large eye of the most powerful telescope refuses to reveal, leaves its impression on the sensitive plate: but the same silvered film will often fail to notice the brightest of Jupiter's satellites in transit, when projected on the planet's disc. Why, then, should the almost beamless nebula be

* Professor of Astronomy, University of St. Louis, Missouri.

photographed, and a bright satellite leave no impression? Because, in the first instance, there was contrast between the faintest pencil of light and a dark background; in the second place, this contrast was wanting; the two discs reflecting nearly the same amount of light.

Thus far I have advanced no new theory. I have stated a fact which Prof. HOLDEN has alluded to in his article on the eclipse of December 21st, a fact well understood by the scientific fraternity at large.* If I have insisted upon this point, it is because I consider it the key to the solution of the problem of photographing the extension of the outer corona.

Much has been said and written concerning the instrument best adapted to the photographing of the corona—whether the reflector will give better results than the refractor—whether large objectives are preferable to smaller ones, etc. Again, the question of diaphragms has been much discussed; and, as to the limit of proper exposures, the conflicting opinions are, "*Sine fine dicentes.*" But how little has been said about the proper development of the photographic plate after exposure, and yet success depends principally upon this trying operation!

It is one thing to make a proper exposure, and another to secure, in the development of the latent image, its most delicate details. It requires judgment and a practised eye to know when to retard and when to accelerate the developer. If the negative is under-developed, the niceties of the faintest shadows are not brought out. Let the negative be over-developed, then those minute details and slightest contrasts are all lost in one common blur. Do you desire to bring out a cloud effect in a landscape, then your exposure must be very short; nay, instantaneous; but you are apt to lose the finest details of the woodland scene. If, on the contrary, you are endeavoring to bring out the softest contrast of the tinted leaves of that autumnal forest, your exposure will be longer, your developer will be retarded by Potassium bromide, but, meanwhile, your clouds will be lost in a perfectly black sky. There lies precisely the difficulty of photographing a total eclipse of the sun. You aim at capturing the full extent of coronal streamers, and, at the same time, you expect the polar filaments to be well defined on your cliché. In the one field a perfect negative is to be obtained of four different light-giving objects, differently illuminated, requiring four different exposures, viz: the actinic protuberances; the bright inner corona; the polar filaments; and the extremely delicate shadings of the extended

* See Publ. A. S. P. vol. II, pages 94 *et seq.*

streamers. To attack the problem with any hope of perfect success, especially when the full extent of the outer corona is desired, I would propose the plan of Horatius encountering the three Curiatii,—separate the enemy. If the maximum extension of coronal streamers be desired, the outer corona must be photographed independently. The inner corona should be just on the margin of the field. Its position, though out of sight, should be well defined; otherwise all future measurements would become impossible. The exposure for a Seed's 26 may range between 30 and 50 seconds, whereas the full eclipse could be captured in 3 to 5 seconds. With skillful manipulation, I have no doubt that a negative can be obtained giving greater extension to the streamers than photography has yet been able to accomplish.

Now we may turn to the question of exposure. No doubt we should always aim at a correct exposure. In developing a well-timed plate we may expect a minimum of difficulties: but how seldom in out-door photography will an exact exposure be obtained! In photographing a bright object, the difference of a second of time may either under or over-expose a plate. In the hands of a skillful operator this accidental time will be counteracted by proper manipulation.

Many factors enter into the calculation of a correct exposure, viz: the altitude of the sun, the condition of the atmosphere, the light-ratio of the lens, the size of the stop, the focal length of the objective, the proper illumination of the object to be photographed, etc. Atmospheric disturbances are, perhaps, the most important factors to deal with in celestial photography. When the altitude of the sun is small and the atmosphere is disturbed, it is impossible to obtain a great extension of coronal rays. But let us suppose that all the conditions are most favorable; that the objective is well corrected for spherical aberration and chemical rays; totality happens in summer; the sun is near culmination in an Italian sky; still there remain serious difficulties which will always make a total eclipse the most difficult picture to be taken in the whole range of photography.

I am inclined to favor long exposures whenever very faint details in the shadows are to be photographed. A long exposure does not necessarily imply an over-exposure; but often leads to it. I should not fear an over-exposure so long as I could prevent a fog. I believe that more delicate details may be obtained from over-exposure than otherwise. The negative may be flat, wanting in density, but this defect may be corrected later on by intensifying the negative. Over-exposure, however, has its limits. It does not follow, by any means, that if an exposure of one minute, to coronal rays, gives a fair amount of extension to the streamers, that doubling the time a greater extension will be obtained. No, you have crossed the limit of over-exposure, and a fogged plate is the inevitable consequence.

One of the negatives of Prof. PRITCHETT's party, taken at Norman, Cal., January, 1889, received an exposure of 30 seconds. Although the polar filaments are almost blurred from over-exposure, and the Eastern motion of the moon has left its trace on the inner corona, still this cliché gives the greatest extension to the outer corona. This, however, must be noticed, that bright objects, such as a cloud near the sun, will hardly admit of over-exposure on account of the intense diffused light in the field. Very sensitive plates, such as a Seed's 26 are unfit for such work; I should rather use a Seed's 23, with a very small stop and a quick shutter; or, still better, a Vogel's Orthochromatic plate.

Another point of vital importance to be attended to, is the necessity of shielding the sensitive plate from all foreign light. A Seed's 26 will be affected by any light whatsoever; even by the so-called non-actinic red light of the dark room. This may not be noticed on the high lights of the picture, but the soft and delicate shades in the deep shadows will most certainly suffer, if the negative be exposed uselessly to the non-actinic light of the dark room. I would recommend to insert the plates into their carriers and to begin the process of development in total darkness.

Allow me to cite an example which I think is to the point. Of all the different parties, which took part in the California eclipse of 1889, Prof. PICKERING's station at Willows was certainly the best equipped. The long experience and skill of this able Astronomer, raised the expectation of all, and naturally invited us to look for the best results from that quarter, but a fatal oversight prevented the expected results. Instead of having a shutter attached to his 13-inch telescope, a plain board was placed 9 inches from the objective, in order to mask the sensitive plate between the different exposures. The diffused coronal light which entered the instrument sideways and affected the plates as soon as the slide was removed, was sufficient to give a slight fog to his negatives, and thus marred the beauty of his best eclipse pictures.

Another consideration which may have escaped the notice of experimenters, is that the exposure is greatly modified by the developer.

The same exposure may give all the result of an under-timed picture with one developer, and of an over-timed negative with another. An experiment of last winter will make my meaning clear. With a six-inch objective, 92-inch focus, I made four exposures on the crescent moon. All the plates used were Seed's 26; time one-fourth of a second. In developing plate no. I, I used a cold pyrogallic solution. Result—an under-timed plate; no details. The second plate was developed with a normal solution of Hydroquinone. Result,—more details, but still under-timed. Plate no. III, was brought out by Eikonogen. Result,—perfect details, appearance of a well-timed negative. For Plate no. IV, I used the same Pyrogallic developer used on Plate no. I, only it was heated to 130 degrees. Result, an over-exposed negative which had to be retarded with K Br. This proved to be the best negative, on account of the richness of its details. I should add, however, that all brands of plates will not stand this high temperature. In winter, Seed's and Cramer's plates will give beautiful results, with this warm treatment, especially for instantaneous work. The gelatine film becomes very soft, hence great care is required in all subsequent washings.

By way of recapitulation, I may recommend the following, in order to obtain greater extension of coronal streamers.

I—To use Orthochromatic plates. I consider Vogel's Eoside of silver the best, when fresh, or Seed's 26, when developed with a warm pyro developer in winter.

II—The greatest precaution to guard from all foreign light.

III—Short exposures to obtain the polar filaments and the inner corona.

IV—Long exposures to secure the extension of the outer corona.

V—Photographing each wing separately, and keeping the brighter part of the eclipse out of the field.

ST. CHARLES, MISSOURI, October, 1890.

THE KENWOOD PHYSICAL OBSERVATORY.

BY GEORGE E. HALE.

At the request of Prof. HOLDEN, I am glad to write the following account of our new observatory in Chicago. The special nature of the work for which it is designed may give this paper an interest it would not otherwise possess.

In the summer of 1888 we erected a small brick building for spectroscopic purposes on the corner of Drexel Boulevard and 46th Street. It contains a general laboratory, "slit-room," "grating-room," and photographic dark-room. With the exception of the laboratory, the walls and ceilings of all the rooms are painted dead black, and light-tight shutters and curtains on the few windows assure almost perfect darkness. A concave grating, mounted as described by Prof. ROWLAND, is the principal instrument. The grating-room contains three brick piers situated at the vertices of a right triangle, the right angle being at the north-east corner of the room. Two heavy wooden beams are supported on the piers, and form the sides about the right angle. To each beam an adjustable steel rail is bolted, and these would meet, if produced, at the apex of the right angle. At this point the slit is placed. It is very accurately made, with jaws of glass-hardened steel, and is capable of rotation about a horizontal axis, by means of a tangent screw, in order to set it exactly parallel with the lines of the grating. The partition between the slit-room and grating-room is so built that it comes directly behind the slit, the light entering the grating-room through a short tube passing through the partition and screwed to the back of the slit-plate. Thus the slit is entirely without the grating-room, and any light-source can be used before it without the least danger of fogging the photographic plate on which the spectrum is received. A carriage moving on the north and south rail carries the grating, and is connected with a carriage on the east and west rail by a girder about ten feet long. On the latter carriage is held an eye-piece for observing the spectrum, or a plate for photographing it. The concave grating was ruled by Prof. ROWLAND. The ruled surface is 3⅝ inches long and 1⅜ inches wide, and has a radius of curvature of about 10 feet. It contains 14,438 lines to the inch, thus making available the whole of the first two orders of spectra, and a portion of the third and fourth. For work on very faint light-sources, such as the electric discharge in rarefied gases, a second grating of only 5 feet radius is used, of course with a short girder. This grating gives almost all of its light in one of the first spectra, and is exceptionally useful for the purpose mentioned. The grating-holder can be rotated about either one of three axes, and, when in use, the face of the grating is at right angles to the girder. With the long focus grating, photographic plates 10 inches long can be used, by bending them to a curvature of about 5 feet. Different regions of any spectrum are brought on to the plate by moving the carriage along the track. The focus is the same at all points, and the photographed spectrum is normal.

A building near by contains the dynamo from which electric currents are obtained. It is a 70-volt WESTON machine, and is driven by a gas-engine of 6-horse-power. A set of 35 JULIEN storage cells can also be used when desired. The current is led into the slit-room to a specially constructed arc lamp or a large induction coil, suitable resistance being interposed in each case. The image of the arc or spark is thrown on the slit by a quartz lens, and the spectra are readily photographed edge to edge with the solar spectrum. Sunlight is thrown on the slit by a heliostat, placed on a pier far enough to the north of the building to be out of the shadow. Suitable absorbing solutions before the slit serve to cut out the overlapping spectra.

When photographic enlargements of spectra are required, they are made in the slit-room by the aid of camera lenses. A GEISSLER pump is employed with various forms of vacuum tubes for the study of gaseous spectra. In such cases the required exposure is much reduced by using the short focus grating. The rooms are so connected by double doors that it is possible to pass through them all without disturbing any plates which may happen to be exposed. They are lighted by incandescent lamps when necessary.

A considerable amount of experimental work was carried on in this building during the summer months of 1888 and 1889. The capacity of the apparatus was fully tested by a long study of the solar spectrum, notably in the region of H and K. The arc spectra of many metals were also photographed, and the reversals investigated. But my absence from the city during a large portion of each year, made it impossible to conduct any continued research, and the apparatus has always been dismounted in the winter.

In the summer of 1889 Mr. BRASHEAR built for me a large telespectroscope, which was used last winter in solar work at the Harvard College Observatory. This instrument has already been described, as well as the research conducted with it. (Technology Quarterly, No. 4, 1890.) A frame of strongly braced steel tubing carries the two telescopes, which make with each other a constant angle of 25°. The objectives are exactly alike, about 3¼ inches clear aperture and 42½ inches focus, and are made of Jena glass. The grating is of the same size as the large concave grating described above, but is, of course, plane instead of concave. The jaws of the slit move equally in both directions from the center, and the whole slit-plate can be moved across the end of the collimator by a screw. A large 30° prism is now being made for faint stellar spectra. The whole instrument is a model of excellent workmanship, and optically it leaves nothing to be desired.

The work at Cambridge was to test a new method of photographing the solar prominences devised by the writer in 1889. But a horizontal telescope was used, and the distortion of the mirror by the sun's heat made it impossible to secure photographs of any value. It seemed very desirable to continue the work with an equatorial, and a few months ago it was decided to considerably enlarge our old building, and add a 12-inch refractor in a dome 26½ feet in diameter. To this instrument the spectroscope will be adapted. Mr. J. A. BRASHEAR, who has so skillfully constructed all of our more important optical apparatus, is now at work on the new object-glass. It is to have the rather long focus of 18 feet, as this is allowed by the size of the dome. Messrs. WARNER & SWASEY are to supply the dome and mounting. The latter is made extra heavy; in fact, it is of the size ordinarily used for a 15-inch glass. The spectroscope and tube are to be mounted as if in one piece, the declination axis coming at the center of their combined lengths. This will give great rigidity, and render necessary very little weighting at the object-glass. The tower for the dome is two stories high, and has stairs leading directly to the dark-room for convenience in photographic work. The lower room of the tower is to be fitted up as a workshop with a lathe and a good assortment of tools. It is intended in the future to derive power from an electric motor, and drive a drill press, shaper, engine lathe, etc. The equatorial pier is very substantially built on broad concrete foundations, and encloses a sidereal clock. As the observatory is designed solely for spectroscopic investigations it will contain no meridian circle of transit instrument, except, perhaps, a small transit for time observations. A room is to be provided with cases for a library, and our special subjects are already well represented by a good number of volumes. All pamphlets and books are made easy of reference by a complete card catalogue, and this is found to be a great convenience in the case of pamphlets, even in so small a collection.

As soon as the equatorial is in place the work of photographing the prominences will be recommenced, and this will be the special research of the winter. A study of various organic dyes is now in progress, as plates very sensitive to the region of the spectrum near the solar line C are desired for the prominence experiments. The large concave grating is also being used in an investigation of arc and spark spectra, in comparison with the solar spectrum.

If any members of the A. S. P. happen to be in Chicago, I shall be pleased to welcome them to our observatory if they care to visit it.

CHICAGO, November 4, 1890.

THE LAW OF THE SOLAR CORONA.

PROFESSOR FRANK H. BIGELOW.*

In compliance with a request from Professor HOLDEN, I send a brief summary of results of some studies on the Solar Corona, referring the Society to the paper published in the Amer. Journ. Sci., Nov., 1890, for the mathematical details. This computation refers to the La Junta photograph of July 29, 1878, but similar calculations are sufficiently advanced on the coronas of 1889 to state that they all seem to conform to the same analysis, and that the same equation is applicable to each.

The Newtonian law of the potential in its inverse action, when applied to a polarized sphere, is laid at the basis of the work, and as its proof by several methods is given in connection with its use in electricity and magnetism, we are now concerned only in the identification of the direction of the coronal streamers with the lines of force produced under these conditions. The repulsion of the surfaces of infinitesimally small particles, obeying this law, is all that is required as a fundamental conception, by way of a physical interpretation of the facts themselves.

The formula must also take account of the distortion of the rays which spring up from the sun at any part of its surface, so far as may be assumed, but are seen from the earth as if projected on the plane through the centre of the sun, perpendicular to the line of sight. Also the coronal poles may not be taken as coinciding with any line of the above plane of the disk, but we do see the plane in which they lie perpendicular to the disk, and must compute the angular distance from the disk to the coronal pole. The poles of the sun's axis of rotation, of the plane of the Ecliptic, and the plane of the equator at the centre of the sun being given, we may, from their projections on the disk, find the heliographic longitude and latitude of the coronal poles at the time of the eclipse.

*Nautical Almanac Office, Washington, D. C.

The photographs were measured on the Stackpole Transit of Venus Engine. The plane of the coronal pole is selected by inspection of the general symmetry of the rays; on a given ray the polar co-ordinates are measured off for at least three points. This gives (γ_1 θ_1) for the first point. Substituting in the formula $N = \frac{8\pi}{3} . \frac{\sin^2\theta}{\gamma}$, if the points all lay on a ray seen without change by projection, the values of N should be the same, and this is the order of the ray. These values of γ. θ. do not give the same N, because a ray seen in its projected position lies across several N's, and we therefore compute a series of orders of rays.

If α is the angle at the disk through which a plane must be turned to change from the disk to the plane of a coronal ray, we find

$$\sec^2\alpha = \frac{X_2^{\frac{4}{3}} Y_1^2 - X_1^{\frac{4}{3}} Y_2^2}{X_1^{\frac{4}{3}} X_2^2 - X_2^{\frac{4}{3}} X_1^2} \text{ where,}$$

$X_1 = \gamma_1 \sin\theta_1$, $Y_1 = \gamma_1 \cos\theta_1$, the successive measured points having appropriate suffixes. If the pole of the corona coincided with the axis of rotation of the plane the values of α should agree, but they also form a series from which it is easy to interpolate the proper one, the choice being finally checked by the resulting values of the angle at the base of the ray on the sun.

The formula for N now becomes $N = \frac{8\pi}{3} . \frac{X_1^2 \sec^2\alpha}{(X_1^2 \sec^2\alpha + Y_1^2)^{\frac{3}{2}}}$, and after the introduction of the angle α the ranging of the N's has ceased.

Having thus obtained the order of the ray, we pass along the ray to the surface of the sun by taking $\gamma = 1$, and compute the angle θ by $\sin^2\theta = \frac{3N}{8\pi}$.

The peculiarity discovered by this equation is that all the rays of the corona are confined to a belt between 28° and 40° polar distance for each hemisphere, counted from the coronal pole, the maximum number being along the parallel of 33° or 34°, thus furnishing an analogy to the terrestrial aurora, if not its very progenitor.

Now taking

$$X_1 = \gamma_1 \sin\theta_1$$

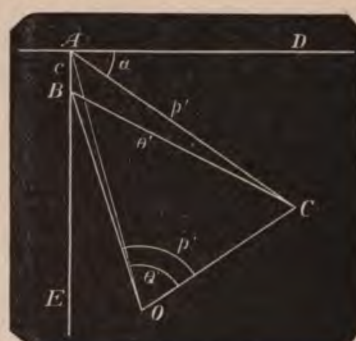
$$Y_1 = \gamma_1 \cos\theta_1$$

$$Z_1 = X_1 \tan\alpha$$

$$D_1 = X_1 \sec\alpha \quad \text{we find,}$$

$$\tan p_1 = \tan \theta_1 \sec a$$
$$\gamma_1 = X_1^2 \sec_2 a + \mathring{Y}_1^2$$
$$\sin^2 \theta^1 = \frac{3\gamma}{8\pi} . N.$$

γ_1 θ_1 are the measured values of the first point, a is the angle at the pole on the disk between the plane of the disk and the plane of the ray, p_1 is the angle at the center of the sun between the axis of the pole on the disk and the radius to the point before projection, γ_1 is the radius of this point, θ^1 is the angle at the center of the sun from the axis of the corona to this radius.



A E = direction of projection.

A = projection of coronal pole B on the plane of the disk A D.

C = point measured, seen in projection.

In the spherical triangle we have given $\theta^1, p^1, 90 - a$, for each point discussed. The solution is, $\sin B = \sin p^1 \sin (90 - a) \operatorname{cosec} \theta^1$

$$\tan \tfrac{1}{2} c = \frac{\cos \frac{1}{2} (A + B)}{\cos \frac{1}{2} (A - B)} \tan \tfrac{1}{2} (\theta^1 + p^1).$$

This value c is the angular distance from the plane of the disk to the pole of the corona.

From these data we compute, by a rather complicated series of triangles, the latitude and longitude of the poles of the corona. The following tables give the collected results. It should be borne in mind that they were obtained for July 29, 1878, by measures on the La Junta Photograph, which shows the covering moon with a diameter of 0.362 inch, the available corona not extending over three-fourths of an inch. With large photographs very accurate readings can be made; the formulas are very sensitive to the effects of small changes in the angles.

Resulting Values of the Polar Distance of the Base of the Coronal Rays on the Sun from the Coronal Pole.

Ray.	S. W. Quad.	S. E. Quad.	N. E. Quad.	N. W. Quad.
	θ	θ	θ	θ
I	35 0	31 41	——	33 5
	31 41	33 25	30 48	30 17
	30 21	29 28	28 35	30 2
II	29 22	30 28	——	28 2
	31 23	32 34	28 32	27 41
	30 44	22 23	19 27	26 11
III	33 59	34 25	28 43	36 30
	32 26	34 59	32 55	34 5
	30 50	31 48	30 59	32 5
IV	30 16	33 45	31 8	34 52
	31 25	34 1	33 39	33 30
	30 14	31 38	30 32	32 26
V	33 51	34 1	32 41	34 24
	35 51	34 19	33 17	35 0
	33 20	33 25	31 32	34 23
VI	36 33	34 52	33 25	33 5
	36 35	34 54	33 18	31 29
	35 41	32 38	34 34	
VII	——	35 8	36 0	41 55
	38 59	35 13	36 23	41 58
	38 57	35 11	35 16	40 49
VIII	41 6	39 7	42 25	
	41 7	39 11	42 23	
	40 30	38 39	40 16	
		37 26		

Angular Co-ordinates of these Rays.

Ray.	S. W. Quad.		S. E. Quad.		N. E. Quad.		N. W. Quad.	
	α	θ	α	θ	α	θ	α	θ
	°	° ′	° ′	° ′	°	° ′	°	° ′
I	87	32 41	88 50	31 31	89	29 42	75	31 8
II	84	30 30	88 20	31 30	85	30 52	65	27 18
III	82	32 25	79	33 44	81	31 45	73	34 40
IV	78	30 38	71	33 8	75	32 50	68	33 26
V	75	34 21	66	33 55	64	33 46	59	33 37
VI	59	36 16	62	34 8	49	35 53	30	41 34
VII	48	38 58	42	35 11	24	41 41		
VIII	33	40 54	40	38 18				

Location of the Coronal Pole as determined from the several Rays.

Ray.	S. W. Quad.	S. E. Quad.	N. E. Quad.	N. W. Quad.
	c	c	c	c
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
I	2 51 18	1 37 56	1 35 0	2 24 2
II	1 58 4	0 0 0	1 20 14	—0 6 38
III	2 56 34	0 51 38	1 24 30	2 24 30
IV	2 45 20	0 49 34	1 5 16	4 2 34
V	1 12 16	0 54 26	—0 5 28	2 17 1
VI	1 8 56	0 58 48	1 8 58	1 0 32
VII	—0 23 42	2 51 32	2 46 18	
VIII	0 30 34	1 23 50		
	1 44 58	1 10 58	1 9 21	2 0 20

Mean for South Pole } 1° 27′ 58″. Mean for North Pole } 1° 34′ 51″.

Resulting Heliographic Co-ordinates.

	North Pole.	*South Pole.*
Longitude	66° 56′.2	168° 11′.1
Latitude............	+85° 44′.6	80° 39′.5

Difference of Longitude, 101° 14′.9.

Difference in Longitude of the Poles of the Terrestrial Magnetism, 111° 51′.

It will be seen by computation that the extremities of the coronal rays are vertically above the sun spot belts at the Minimum of the Period.

NOTICES FROM THE LICK OBSERVATORY.

PREPARED BY MEMBERS OF THE STAFF.

THE INTERNATIONAL ASTROPHOTOGRAPHIC CONGRESS (1889) AND A VISIT TO CERTAIN EUROPEAN OBSERVATORIES, ETC.

Under this title Lieut. WINTERHALTER, U. S. N., has printed a report of some 350 pages as Appendix I to the Washington Astronomical Observations for 1885. It is divided into three principal parts. Part I relates to the Transactions of the International Astrophotographic Congress, and is a useful English translation and summary of what has already been printed in the *Bulletin* of the Congress. Part II contains Notes of a Visit to Certain European Observatories, etc., together with admirable illustrations of some of the more important buildings and instruments; and Part III relates to Sundry Astronomical and Nautical Constructions and Processes.

The volume is mentioned here on account of its Part II, which gives an excellent general idea of the present state of many of the principal observatories in Europe, and which will be interesting to any of the members of the Society who can see it, if only to compare the constructions and designs there described with those with which they are familiar on Mount Hamilton.

Through the kindness of Captain McNAIR, Superintendent of the U. S. Naval Observatory, we have received permission to have electrotypes made from some of the cuts which illustrate this work, and it is the intention of the Committee on Publication to reproduce some of the more interesting pictures in the *Publications* A. S. P., from time to time, accompanied by very brief descriptions. In this way some of the excellent results of Lieut. WINTERHALTER's report will be made available to all the members of the Society.

E. S. H.

Bright Meteor Observed in Daylight.

The following is extracted from a letter lately received from Mr. C. F. Merrill, agent of the S. P. Co. at Colma:

* * * "Some little time ago duty compelled me to remain on watch all night at this station. About 6:13 A. M. on September 14, while sitting at the window of the waiting-room, which faces directly south, my attention was attracted by a loud sputtering noise (the waiting-room door being open.) Looking into the sky, I saw a body passing through the air in a southwesterly direction, inclining downward. It was not round, but in the shape of a banana, turning end on end. It also appeared to be a mass of red-hot composition, from which I could clearly see particles flying. It must have been very large, as I could distinctly see its shape and outline as it turned in the air. It was broad daylight at the time.

"What was it?"

Astronomy and Numismatics.

Dr. A. Vercoutre, in *L'Astronomie* for September, 1890, points out how astronomical knowledge may be of service to numismatical science. It is known that on many antique medals, and notably on the coins of the Roman Republic, stars and members of the solar system figure sometimes as symbols and sometimes as heraldic allusions to the magistrate by whom the coin was struck. Thus, on a coin struck by L. Lucretius Trio, 74 B. C. the seven stars in *Ursa Major* are shown, and this constellation, being named Septem Triones, was evidently used as a phonetic allusion to the surname (Trio) of the magistrate. Again, on a coin struck in B. C. 43, Dr. Vercoutre noticed five stars, one of which was much larger than the others. He therefore concluded that the constellation represented on the coin was *Taurus*, as this was the only group of five stars known to the ancients, in which one was more brilliant than the others. On this account he was able to attribute the coin to P. Clodius Turrinus, who apparently used the constellation *Taurus* or *Taurinus* as a phonetic signification of his surname. A coin struck by Manius Aquillus, B. C. 94, has figured upon it the first four stars in the constellation *Aquila*.—From *Nature*, October 2, 1890.

THE MOTION OF THE SOLAR SYSTEM IN SPACE [BY OSCAR STUMPE].

The *Astronomische Nachrichten* nos. 2999–3000 contains a very thorough investigation of the motion of the solar system in space, of which a brief analysis will be given here. The principle at the bottom of this investigation is that first worked out by Sir WILLIAM HERSCHEL and depends on the fact that the stars which lie in the region *towards* which the solar system is moving will, on the whole, seem to separate from each other, while the stars in the region *from* which the system is moving will, on the whole, seem to crowd together, while, again, the stars on the two sides, as it were, will, on the whole, keep their relative distances. The case is analogous to that of a traveller moving in a straight path through a forest of trees. Those in front of him will seem to separate and those behind will seem to crowd together, owing to appearances caused by his own motion. The trees in a forest are fixed and all the apparent motions are apparent only—parallactic—caused by the movement of the traveller. Each star, however, has a motion of its own—*motus peculiaris*—as well as a motion due to the displacement of the observer—*motus parallacticus.*

The first step, then, in an investigation of the sort, is to obtain determinations of the observed stellar motions which are as precise as possible. As the total motion of a star in a hundred years even, is itself a small quantity, it is of the first importance to determine this datum with accuracy. Dr. STUMPE has chosen for consideration all stars whose proper motion in a century is as great as 16″. There are 1054 such stars whose positions and proper motions for 1855.0 are given, after having been reduced to the system of NEWCOMB (Washington observations 1870) and BOSS (Declination of Fixed Stars 1877).* Unfortunately they are not regularly distributed over the sky and the great majority of them are northern stars. With these materials, the author proceeds to the solution of the problem. Almost all preceding investigations of the sort, of which there have been many, have been carried on under the assumption that the

* Professor BOSS pointed out to me in a private letter (which I have his permission to use) that Dr. STUMPE has erroneously assumed that the systems of AUWERS and NEWCOMB-BOSS are practically identical for 1755. The difference NEWCOMB — AUWERS has been treated by FARQUHAR in the *Astronomical* JOURNAL No. 209 (see also A. J. No. 213) and the difference BOSS — AUWERS in A. J. 196 (see also *Proc.* A. A. A. S. 1879) It appears that the correction for the Zodiacal Stars necessary to reduce the Fundamental Catalogue of AUWERS to the system of the American Ephemeris is

For R. A. $+0^s.006 + 0^s.0008$ (T — 1875), and

For Decl. $+0''.22 - 0''.013$ (T — 1875) approximately.

The Decl. correction varies, however, quite markedly from north to south.

motus peculiaris of each star was subject to no law, but might equally probably be directed to any point of the sky. If, however, we do not regard the aggregation of the stars in the Milky Way as a merely accidental circumstance, it is logical to suppose that the true motion of a star must stand in some relation to the plane in which the Milky Way lies. This consideration led Sir JOHN HERSCHEL to the hypothesis of a Rotation of the stellar system in the plane of the Milky Way, according to which each star was supposed, in general, to revolve in a somewhat eccentric orbit about the centre of the Milky Way, this orbit being only slightly inclined to its plane. The author has included in his equations (which are in the form first proposed by Professor SCHOENFELD) terms which express such a rotation, as well as the usual terms which express the corrections to the precession constants and the terms which express the Sun's motion in space. The same form of equations has previously been adopted by Dr. BOLTE and by Dr. L. STRUVE. In order to take the next step it would be convenient to make some hypothesis as to the relative distances of the different classes of stars used in the discussion. In Dr. STRUVE's memoir he has supposed the stars used to be situated at certain relative distances from the Sun depending directly on their magnitudes; Dr. BOLTE has divided the stars used by him into three classes according to their magnitudes, namely: 1st, 5.5 to 7.4 mags.; 2d, 7.5–8.2 mags.; 3d, 8.3–10 mags., and has solved the equations for each class separately, thus determining, from the data, the relative average distances of each of his classes. (Dr. BOLTE's results did not, however, show a certain law of increase of distance with increase of faintness.) Dr. STUMPE has chosen another method of estimating the distance of the stars of his list, that is, he has divided them into four classes according to the magnitude of the observed proper motions, thus:

Class I contains 551 stars whose proper motions are between 16″ and 32″ in a century.

Class II contains 340 stars whose proper motions are between 32″ and 64″ in a century.

Class III contains 105 stars whose proper motions are between 64″ and 128″ in a century.

Class IV contains 58 stars whose proper motions are over 128″ in a century.

These data lead to 2108 equations containing 5 unknown quantities, which are to be solved by least squares. Dr. BOLTE and Dr.

STRUVE, in their investigations, made use of certain simplifications which materially reduced the enormous labor of the solution, but, as it is by no means sure that such simplifications did not somewhat influence their final results, Dr. STUMPE has valiantly rejected all simplifications, and has solved these equations just as they stand. This labor is not lost, for it gives his investigation a high authority, since his results are the pure outcome of observed facts, free from all hypothesis.

The solution of the equations shows no sign of any systematic rotation of the stars about the Milky Way. Dr. STUMPE points out that this result may not be due to the absence of such a general rotation, but that it may simply be caused by the fact that most of the stars of his list are northern stars. When the stars of the southern sky have been as completely investigated as those of the northern hemisphere, this work should be repeated in the same thorough manner. Leaving, then, the question of a general rotation of the stars and solving the equations for the Right-Ascension and Declination of the point towards which the Solar System is moving (R. A.; Decl.), and for the velocity of the sun's motion as seen from each group of stars $\left(\frac{c}{\rho},\right)$ Dr. STUMPE obtains—

Class	R. A.	Decl.	$\left(\frac{c}{\rho}\right)$	Mean Magnitude of each Group.	Mean Proper Motion of each Group.
	°	°	″		″
I	287.4	+ 42.0	0.140	6.0	0.23
II	279.7	+ 40.5	0.295	6.7	0.43
III	287.9	+ 32.1	0.608	6.1	0.85
IV	285.2	+ 30.4	2.057	6.5	2.39

The comparison of the column $\left(\frac{c}{\rho}\right)$ with the last column shows not only that the stars with large proper motion are nearer to us than the rest, but the numbers agree well with the hypothesis that the distance of a star is inversely proportional to its proper motion. There is no relation between the magnitudes and the distances of the stars used in the investigation.

The foregoing abstract gives the main results of Dr. STUMPE'S work, but it fails to do justice to the thoroughness and rigorously scientific spirit of the plan of investigation. The final figures set down in the last table would have the highest authority, if the systematic corrections of the original star-places were revised and the work repeated. E. S. H.

ADDENDUM TO LUDLAM'S ASTRONOMICAL OBSERVATIONS (1769).

In 1769, the Reverend W. LUDLAM printed a volume, whose title-page is as follows:

> Astronomical observations made in St. John's College, Cambridge, in the years 1767 and 1768, with an account of several astronomical instruments, by the Reverend Mr. LUDLAM. Printed by J. ARCHDEACON, printer to the University, for T. CADELL, successor to Mr. MILLER, in the Strand, London, MDCCLXIX.

The copy of this work in the library of the U. S. Military Academy at West Point, which I used in the years 1871–2, is full of manuscript corrections, and it contains also a manuscript note, in which the Reverend author sets forth his grievances. I have thought that this should not be unknown, and I copy it below, with the reminder that a considerable part of the income of the Universities of Oxford and Cambridge was and still is derived from their exclusive privilege of printing the Authorized Version of the Bible. E. S. H.

MANUSCRIPT NOTE BY THE AUTHOR.

"*The university printer being very ignorant, and the press meanly*
"*provided with types for books of science, there are many inaccuracies*
"*in the printing of this book; some of which are corrected with the*
"*pen.*

"*The gainful monopoly of printing bibles and common prayer*
"*books, is the only object that engages the attention of the University*
"*officers and their greedy printer.* *W. L.*"

THOLLON'S MAP OF THE SOLAR SPECTRUM.

The third volume of the *Annals of the Observatory of Nice* is accompanied by a magnificent folio-atlas, containing a map of the solar spectrum. This atlas is the fruit of some six or seven years' work by M. THOLLON; and, after his death, M. PERROTIN, the Director of the observatory of Nice, employed parts of three or more years in completing it for publication. It is not possible to give in this place an adequate review of this great work. An excellent short account of it is given in *Knowledge*, for Sept. 1, 1890. The observatory of Nice was founded by M. BISCHOFFSHEIM of Paris, and he has already spent more than $1,000,000 for buildings and instruments. Among the latter is the great telescope of 30 inches aperture. The publication referred to is, I believe, also made at M. BISCHOFFSHEIM's private cost. A brief description of the Nice Observatory will probably be printed in these *Publications* during the current year.

E. S. H.

SATELLITES OF MARS, 1890.

During the present opposition the maximum theoretical brightness of the satellites of *Mars* was 1.15, if their brightness at mean opposition be taken as 1.00.*

Their brightness at discovery was 1.91. Under good circumstances they have been readily visible in the same field of view with *Mars*, when the planet was not hidden by an occulting bar. They have been several times re-discovered by visitors who were looking at the planet, and who did not know of their existence.

During April and May two observers made a conscientious search for new satellites. The weather conditions were rather unfavorable. The general conclusions reached were that no new satellite exists within the orbit of *Deimos*, which is anything like as bright as one-fourth the brightness of that satellite. It is possible, though not very likely, that so faint a satellite as this may exist outside of *Deimos'* orbit, or within that of *Phobos*.

E. S. H. AND J. M. S.

SOLAR PARALLAX FROM THE TRANSIT OF VENUS PHOTOGRAPHS OF 1882.

Professor HARKNESS, U. S. N., reports that the photographs of the last transit of *Venus* (more than 1400 photographs being available) lead to the following value of the solar parallax; $\pi = 8''.842 \pm 0''.0188$. With 3963.296 miles as the equatorial radius of the earth, the resulting mean distance of the sun is 92,455,000 miles, with a probable error of 123,400 miles.—(From the *Report of the Supt. U. S. Naval Observatory*, June 30, 1889.

SPECTROGRAPHIC OBSERVATIONS OF *SPICA* AT POTSDAM.

In No. 2995 of the *Astronomische Nachrichten* Professor H. C. VOGEL considers at length all the photographs of the spectrum of α Virginis which have been made at Potsdam, and finds that they

* *See* a paper by Mr. KEELER, in the *Astronomical Journal*, Vol. VIII, p. 74.

accord closely with his earlier observations of the same star, showing that it is a close binary, having a period of only a little more than four days. The same apparatus was employed as in the determination of motions of stars in the line of sight, described by Professor VOGEL in *Astronomische Nachrichten*, No. 2896. In the method followed at Potsdam, the spectrum of the star and that of terrestrial hydrogen are photographed together, and the displacement of the star lines on the photograph in the neighborhood of the Hγ line, is afterwards measured under a microscope. Stars of the second and third spectral types gave results of great accuracy, as the lines in such stars are sharp and are very numerous. In the case of α Virginis, the difficulties of observation were considerably greater, the hydrogen lines being broad and diffuse, without any definite maximum of intensity, and there were no distinct lines in the vicinity of Hγ to which the measurements could be referred.

Measurement of twenty-four photographs, obtained during the spring of the present year, showed that the star lines were displaced alternately toward the upper and the lower end of the spectrum in a complete period of about four days, the maximum displacement toward the violet indicating a motion of the star toward the sun of 65.9 English miles, and that toward the red a receding motion of 47.5 miles per second. These observations are completely explained by supposing that *Spica* is a binary star having a period of about four days, the orbital velocity of the larger component being 56.7 miles per second, and that the system is approaching the sun at the rate of 9.2 miles per second. The more exact elements, as determined by Professor VOGEL, are as follows:

Potsdam Mean Time.

Epoch t_0 (no orbital motion in line of sight) = 1890, May $4^d\ 10^h.50$. Period $p = 4.0134$ days.

Motion of System in line of sight = − 9.2 Eng. miles.

Motion in the line of sight, at time t, after deducting the motion of the system $= 56.7 \sin\left(\frac{t - t_0}{p} 360^\circ\right)$ Eng. miles.

A comparison with the Greenwich results for this star in preceding years was made with the aid of this formula, but it was unsatisfactory, owing to the uncertainty of the English observations.

On the assumption of a circular orbit, equal mass of the components, and the data given by observation, the mass of the system is 2.6 times that of the sun, and the distance between the components

6,260,000 miles, which assuming a parallax of 0''.2, corresponds to an angular separation of 0''.014, a quantity inappreciable in even the most powerful telescopes.

Professor VOGEL points out, finally, that traces of the spectrum of the companion can be seen on his plates, in the unsymmetrical appearance of the hydrogen line at a time of maximum motion, and the greater sharpness of other and finer lines at a time of minimum motion, and concludes that the companion, if we could see it, would be of the third magnitude.

Translating the mathematical formulæ of Professor VOGEL into the ideas which they represent, a wonderful picture of stellar motion is presented to our mind, and one to which the whole visible universe, as revealed to us by our greatest telescopes, offers no parallel. The spectacle of two great suns like our own, revolving around each other in only four days, at a distance no greater than that which separates the sixth satellite of *Saturn* from its primary, is one which the inadequacy of our optical powers will probably ever forbid us from actually beholding, but the indirect evidence that such extraordinary circumstances of motion exist, is so complete that we must admit their reality. If our knowledge of the rings of *Saturn* rested on evidence of similar character, and not on actual observation with the telescope, the facts to be accepted would seem equally strange and beyond our experience. The system of *α Virginis* offers abundant material for speculation. How great, for example, must be the tide-raising forces on the surfaces of such bodies! Actual tides would probably not be found, since it would seem as if the friction of such tides as the forces there acting would produce, would quickly bring the rotation times of both bodies into coincidence with their period of revolution; but both bodies would be distorted far out of a spherical form, and greatly elongated in the line joining their centres. If the distance of the two components were three million instead of six million miles, the bodies probably could not exist as separate masses, but would be torn to fragments by the enormous stresses. This discovery of Professor VOGEL'S, together with similar discoveries by Professor PICKERING, (which are briefly described in Publ. A. S. P. Vol. II, p. 125) opens an entirely new vista in sidereal astronomy, and will lead to wider views of the constitution of the universe.

J. E. K.

ANNOUNCEMENT OF AN ENGLISH TRANSLATION OF DR. DZIOBEK'S TREATISE ON THE MATHEMATICAL THEORIES OF PLANETARY MOTIONS [BY PROFESSOR M. W. HARRINGTON, DIRECTOR OF THE OBSERVATORY OF THE UNIVERSITY OF MICHIGAN].

Dr. DZIOBEK'S treatise appeared in the German language in 1888, and has been very well received. Its original publication was aided by a grant from the Prussian Department of Education. It is an interesting fact that an American publisher has been willing to issue, at his private risk, and without guarantees, an English translation of this work, which has been made by Professor HARRINGTON, and revised by the author.

The book is not in any sense an elementary one. Its scope is best indicated by the following extracts from the author's preface:

"The problem of the motion of the heavenly bodies is of great importance in itself, but it is of especial importance to the mathematician. The attempts to solve it, though not entirely successful, have afforded occasion for a display of unsurpassed ability, and have given a great impulse to mathematics. Analytical mechanics, beginning with Newton and receiving its final form from Lagrange, is especially indebted to this problem which afforded it the very foothold necessary for its advancc, and though not yet completely solved, it has proved so fertile in suggestion and impulse, that it has determined, to a great degree, not only the direction, but also the rapidity of the advance of mathematics.

" Hence, when it is desired to illustrate the abstract theories of analytical mechanics, the profundity of the mathematics of the problem of the motions of the heavenly bodies, its powerful influence on the historical development of this science, and finally the dignity of its object, all point to it as most suitable for this purpose.

"This work is not so much intended for the specialist in astronomy as for the student of mathematics who desires an insight into the creations of his masters in this field. The lack of a textbook which would give, within moderate limits and in a strictly scientific manner, the principles of mathematical astronomy in their present remarkably simple and lucid form, is undoubtedly the reason why so many mathematicians extend their knowledge of our planetary system but little beyond Kepler's laws. The author has endeavored to fill this gap and, at the same time, to produce a book which shall be so near the present state of the science that the latest investigations shall be included, and even the unsettled questions indicated.

"The subject of the work is that part of celestial mechanics which treats of the motions of the heavenly bodies considered as gravitating points. This is the most important part, and it is fundamental for theories of rotation, of tides, and of the figures of bodies. The author hopes to treat of the latter in a separate work. The simplest processes, and those which best represent the present state of the science, have always been selected and especial care has been taken to guard against the brilliant hypotheses which the explorers of this field have so often indulged in, but which are not suitable for a text-book. The farther advance of the student is aided by the references to the original sources which are invariably given, and which have, almost without exception, been used by the author.

"Farther assistance in this direction is afforded by the sketch of the historical development of the subject which accompanies each important subdivision of the work."

The work is issued by subscription, at a price of $3.50 (orders can be sent directly to Professor HARRINGTON.) It is a matter for congratulation (on several accounts) that the number of orders already received indicates a strong demand for such a treatise in the English language. E. S. H.

BIOGRAPHY OF W. C. BOND.

The *Boston Traveller* is now printing a series of weekly articles (beginning with its issue of August 2) on the life and works of W. C. BOND, the first Director of the Harvard College Observatory. I understand that his granddaughters contemplate the preparation of a memoir of the elder BOND and of his son, Professor GEORGE P. BOND, who was the second Director of the same observatory. E. S. H.

SCIENTIFIC EXPEDITION TO THE SUMMIT OF MOUNT BLANC [BY M. JANSSEN].

M. JANSSEN, Director of the Physical Observatory of Meudon, near Paris, has just made a report of his scientific expedition to the summit of Mount Blanc, which is most interesting in every point of view. The original account is printed in the *Comptes Rendus* of the Paris Academy of Sciences, vol. CXI, (1890.) The following is a brief abstract. The object of M. JANSSEN's expedition was to determine whether oxygen exists in the solar atmosphere. When the solar spectrum is examined with a spectroscope, at sea level, some lines are seen which may be due to oxygen in the sun's atmosphere, or which may be due to absorption effects in our own terrestrial air. If the spectrum is examined from terrestrial stations of great elevation, the absorptive effect of the earth's atmosphere is less and less, as the station chosen is higher and higher, naturally. In October, 1888, M. JANSSEN made the ascent of Mount Blanc as far as the *Grands-Mulets* (about 9800 feet above sea), and obtained satisfactory observations; in 1890 he ascended to the very summit of the mountain (15,700 feet), and repeated his work. The immediate scientific result of his two expeditions is that oxygen is not present in the gaseous envelopes which surround the sun; or, at least, if oxygen is present, it is in a condition entirely different from that known to us in our laboratories, and does not produce that absorption of light which is marked by the system of lines and bands familiar to spectroscopists.

This is a scientific conclusion of capital importance in questions of solar physics.

The expedition of M. JANSSEN has an interest quite apart from its purely astronomical one. In fact M. JANSSEN lays the chief stress, in the paper cited, upon the question of the establishment of a high-level observatory at the top of the mountain, and points out the great scientific advantages to be gained from such an observatory, devoted to questions of terrestrial as well as of solar physics. If such an observatory is to be founded anywhere it is tolerably certain that stations can be found which are far more favorable than Mt. Blanc. Pike's Peak, for example, is 14,134 feet high, and the summit can now be reached by a railway. There is no reason why a station on Pike's Peak could not be maintained throughout the year, since the U. S. Signal Service kept its observers there for several years continuously. There are also many stations in the Sierra Nevada of California which have natural advantages far above those of Pike's Peak. It would seem, then, that for scientific purposes alone, it might be better to maintain a station at one of these places (to speak only of mountains in North America), than to attempt to found such a station on the summit of Mt. Blanc, which can be reached only with great difficulty and some danger under the most favorable conditions, and which is practically inaccessible during many months of the year. The chief interest in M. JANSSEN's paper, after its astronomical importance, is, for us, the exhibition of his intrepidity in planning such an ascent at all, and of his cool daring in accomplish-ing it. M. JANSSEN is 66 years of age, and suffers from a severe lameness, so that it is practically impossible for him to make continued exertion in walking. During his ascent to the *Grands-Mulets* in 1888 it was with the greatest difficulty and danger that he attained the cabin at that point, although the ascent is by no means difficult for good walkers. Many ladies, for example, go as far as this. How then was it possible for him to reach the summit, 6000 feet higher, which lies beyond a wilderness of huge rocks and great glaciers with their crevasses, and the route to which runs along steep *arêtes* only two or three feet wide, with terrific slopes on both sides of the narrow crests? To appreciate the splendid daring of M. JANSSEN, it is necessary to read his own words. It is only possible here to give the merest summary of them.

Before leaving Meudon, M. JANSSEN had a sled constructed which resembled in general pattern the reindeer sledge of the Laplanders. In front and behind this were double parallel cords, united by wooden rungs like ladders. A long line was attached to the front of the sled, and another to the rear. The ascent was made as follows: M. JANSSEN was seated in the sled, and twelve selected guides managed its movements. Two guides, far in advance, sunk an ice-axe in the snow as far as it would go and kept two turns of the forward line wound round its handle. When necessary the other line was kept tight also. The remaining guides pulled on the rope ladders front and back, or, when possible, supported the sled at the sides. In this way, foot by foot, the sled was moved. It was necessary for the guides to cut steps in the steep slopes for their feet to rest in. All that the passenger was required to do was to sit still and keep perfectly cool. This was all—but in the face of the frightful precipices with which the route is surrounded—it was enough.

There are few men whose nerves are steady enough to contemplate dangers of the sort when they are themselves precluded from some sort of physical action. I pass by all the incidents of the route; the passage of the well-known obstacles; the two days and a half spent in a small cabin at the station *des Bosses* during the prevalence of a hurricane; the ascent of the final slope; and simply recite that the summit was reached during weather exceedingly suited to the observations, and that the descent (which was more dangerous than the ascent) was safely accomplished. The party had been five days on the mountain.

M. JANSSEN says that he is perhaps the only person who has stood on the summit of Mt. Blanc without having made severe exertions to reach it, and who, therefore, was completely possessed of his intellectual vigor, which is always diminished after bodily toil. He makes no account of the nervous strain of the ascent, or of the anticipation of the far more dangerous descent, and this strain would be a more severe tax on the faculties of most persons than even violent and continued exertions. Those who remember M. JANSSEN'S cool ride ***on horseback*** over the crater-floor of ***Kilauea***, in 1883,* can understand that the danger of Mt. Blanc might seem a little thing to him, but it is difficult to think that his plan for a physical observatory among those perils is a practical one. It is permissible to admire his courage and devotion, and yet, in the name of Science, to suggest that the dangerous summit of Mt. Blanc be abandoned for such a purpose, and that the proposed observatory be established on Pike's Peak, only a few hundreds of feet lower, at the end of a railway and telegraph line already in operation, and in a situation where it is perfectly practicable to maintain observers during the entire year, with few difficulties and with no peril; or, if not at Pike's Peak, then at some station less dangerous than Mt. Blanc. Of M. JANSSEN'S expedition and of his project we may be permitted to say, with the fullest admiration for his courage and for his successes, but with a recollection of the limitations of ordinary men—

"C'est magnifique, mais ce n'est pas la guerre." E. S. H.

ARGELANDER'S DURCHMUSTERUNG MAPS WANTED.

The Lick Observatory is in want of the maps (only) of ARGELANDER'S *Durchmusterung* (first section, $+ 90°$ to $- 2°$), and will be glad to know of a set for sale. E. S. H.

ON THE RING-SHAPED MOUNTAINS OF THE MOON † [BY DR. H. EBERT, OF THE UNIVERSITY OF ERLANGEN].

Dr. EBERT, whose studies have been directed to the question of the mode of formation of the ring-shaped craters on the Moon, has done a very useful work in his last paper on the subject, by discussing all the data afforded by the labors of SCHMIDT, BEER and MÆDLER, WARREN DE LA RUE and others.

The object of the research is to determine if there are any char-

* Very likely this particular escapade of the venerable astronomer is unknown in Europe, though it is well remembered in Hawaii, and serves as a companion-piece to his escape from Paris in a balloon, during the Franco-Prussian war, in order that he might go to India to observe the Eclipse of 1871.

† Ueber die Ringgebirge des Mondes; *Sitzungsberichte d. Physik-Med. Societaet* Erlangen (1890).

acteristic relations between the various dimensions of the ring-craters, as their diameters, the height of the outer walls above the general surface, the height of these walls above the interior of the craters, the height of the peaks in the interior of the rings, etc., etc. The relation between the cubic contents of the outer walls and that of the interior of the crater is also specially examined.

The materials for the discussion are drawn, as has been said, from works already published. These materials are first put into a tabular form for convenience. For each ring-crater, there is given the average interior depth (J); the height of the outer wall above the exterior surface of the Moon (A); the diameter of the crater (D); the height of the central peak (h); the inclination of the outer wall towards the interior (a) and towards the exterior (B) in degrees. These and other data are given for 92 ring-craters—all that could be utilized in this discussion. It should be remembered that some of the data are quite uncertain.

The author next proceeds to form the various ratios, etc., expressed by

$$\frac{J}{A}, \quad J-A, \quad \frac{J}{D}, \quad \frac{D}{h}, \quad \frac{J}{h},$$

$$d=J-A-h, \quad \frac{D}{d}, \quad \frac{J-d}{D}, \quad J-d, \quad \frac{J}{p}, \quad K,$$

and $E = 1 - K$ where K is the ratio of the cubic contents of the outer walls to that of the interior of the crater.

The author's results are briefly as follows:

1st: The ratio $\frac{D}{J}$ varies between 7 and 70; that is, the ring-craters are from 7 to 70 times as broad as they are deep. We must not regard such formations as "deep depressions," etc., but rather as dish-like cavities. In fact there are many ring-craters so broad that a spectator stationed on one wall could not see the opposite one, because it would be hidden from him by the convexity of the Moon's surface.

2d: The smaller ring-craters are relatively the deepest. This is clearly shown in the following little table (J is the depth, D the diameter in kilometers):

Small	craters;	D = about	28 kilometers;	$J = \frac{1}{10} D$;
Average	craters;	D = about	60 kilometers;	$J = \frac{1}{20} D$;
Large	craters;	D = about	105 kilometers;	$J = \frac{1}{33} D$;
Largest	craters;	D = more than	120 kilometers;	$J = \frac{1}{40} D$.

The persistence and perfection of the ring-form in both small and large craters would, at first sight, lead to the conclusion that all were formed in a similar way. The table seems to the author to indicate that different processes have been at work. The ring-craters are not all models copied from one type, but the general form varies with the absolute diameter. The broader the crater the less the interior depth. These facts seem to the author to invalidate the volcanic theory of the formation of such ring-craters. Under such a theory the broadest craters should also be the deepest, whereas the contrary is the case.

3d: While the *relative* depth of the larger craters is less than that of the smaller, the larger craters always have the greatest *absolute* depths.

4th: The height of the outer wall, above the general surface of the Moon, is greater for the larger than for the smaller craters and seems to vary with the diameter in general. Certain interesting exceptions are noted by the author.

5th: The relation of the inner depth (J) to the outer height (A) is next discussed. The smallér the crater the larger is $\frac{J}{A}$; that is, the nearer the form approaches to that of a simple cavity without bounding walls. As the diameter increases $\frac{J}{A}$ becomes smaller. When D becomes about 90 kilometers or larger $\frac{J}{A}$ becomes constant and equal to about 2½. That is, for craters above 50 miles in diameter the depth is pretty regularly about 2½ times the height of the outer wall above the surrounding country.

6th: In a general way, the absolute depth of a crater (J — A) is greater for the larger craters, but there are many exceptions.

7th: The height of the interior peaks (h) is never so great as the depth of the crater (J). $\frac{J}{h}$ is always greater than unity.

8th: The larger the diameter of a crater the greater is the volume of its interior cavity as compared to the volume of its wall. For the smallest craters the volume of wall is many times that of the interior cavity.

9th: To the preceding I add the interesting fact that the average angle of interior slope is 34.5°, and of outer slope 6.9°, taking all the 92 craters together.

The foregoing summary shows that considerable light is thrown upon the laws of formation of the lunar craters by the systematic examination which Dr. EBERT has made of the comparatively small amount of data at his disposition. A careful study of a set of lunar photographs would add greatly to the materials available for such a discussion. E. S. H.

SCIENTIFIC VISITORS TO THE LICK OBSERVATORY.

The great refractor of 25 inches aperture made by COOKE for the late Mr. NEWALL of Ferndene, Gateshead, England, has been presented to the University of Cambridge by his family, in accordance with Mr. NEWALL's wishes, and generous provisions have been made for installing the telescope at Cambridge. Mr. H. F. NEWALL, a son of the donor, has volunteered to give his services for a term of years as Astronomer.

Before beginning his work Mr. NEWALL desired to inspect the great observatories of the world, and he has not hesitated before the long journey to California, in order that he might study the equipment of the Lick Observatory, and particularly the mounting and performance of the great equatorial. The rainy season of California obligingly postponed its coming this year a month later than usual, and although our visitors were on a short allowance of water, they had excellent observing weather. The spectroscope for the NEWALL telescope will be provided by a grant from the BRUCE fund, and will contain some, at least, of the admirable features of the Lick Observatory instrument.

A letter lately received from the Earl of ROSSE announces that he will visit Mount Hamilton during the present winter. This is the second visit of Lord ROSSE to the United States.

The Prussian Government proposes to equip the Potsdam Observatory with a giant-telescope in order that the admirable spectroscopic observations of Professor VOGEL may be extended to the stars of the 4th and 5th magnitude. Before ordering such a telescope Professor AUWERS, Secretary of the Royal Academy of Sciences of Berlin, will be sent by the Government to inspect various astronomical establishments. Among other places, he will visit the Lick Observatory some time during the coming summer. To all our distinguished visitors the astronomers of Mt. Hamilton extend a hearty welcome. E. S. H.

GEORGETOWN COLLEGE OBSERVATORY (WASHINGTON, D. C.)

A recent note from the Director of the Georgetown College Observatory recites that the old 5-inch equatorial (used by Fathers CURLEY, SECCHI and SESTINI) is now being dismounted to give place to the new 12-inch equatorial. The Director, Rev. JOHN G. HAGEN, S. J., proposes to devote the new equatorial to the observation of the fainter variable stars.

Father HAGEN also says that an English translation of F. BRAUN's recent work on Cosmogony (*Ueber Kosmogonie vom Standpunkte Christlicher Wissenchaft*, etc., 1889), is now preparing, and that it will be issued (so I understand) by the care of the staff of the Georgetown College Observatory. E. S. H.

OBSERVATORY OF THE CATHOLIC UNIVERSITY OF AMERICA, BROOKLAND (WASHINGTON, D. C.)

A recent note from Rev. GEORGE M. SEARLE, Director of the observatory, gives its geographical position as—

Latitude 38° 56′ 15″ north.
Longitude 5^h 8^m $0^s.0$ west.

The position of the U. S. Naval Observatory is—

Latitude 38° 53′ 38″.8.
Longitude 5^h 8^m $12^s.09$.

Professor SEARLE has a five-inch refractor in use, but expects soon to mount a 9-inch refractor, just completed by Mr. CLACEY, of Boston. E. S. H.

COMPARISON OF SOME PHOTOGRAPHS AND DRAWINGS OF THE NEBULA OF ORION.

Mr. ISAAC ROBERTS, F. R. A. S., has kindly sent me a number of paper-prints of his remarkable negatives of nebulæ, and among them is a truly wonderful picture of the nebula of *Orion*, from a negative made February 4, 1889, with an exposure of 205 minutes. The instrument used was a reflector of 20 inches aperture and 100 inches focus. The print is an excellent one, but it probably fails to do full justice to the original negative, which, most likely, shows stars something like a full magnitude fainter than the print itself. I have also compared a beautiful print (enlarged seven times), which I owe to the kindness of Mr. COMMON. It was made in 1883, with his 3-foot reflector and an exposure of 37^m. The same remarks as to the loss in printing apply here also. We have lately made, at the Lick Obser-va'ory, a few negatives of the *Orion* nebula, under good circumstances. The exposures have been made by Mr. SCHAEBERLE and myself, and the plates have been developed by Mr. BURNHAM and Mr. BARNARD. I have made a comparison between these negatives, the prints by Mr. COMMON and Mr. ROBERTS, the General Catalogue of Stars in the Nebula by Professor G. P. BOND, and an unpublished drawing of the Nebula, by Dr. J. F. J. SCHMIDT.

A brief summary of the results of the comparison may be of interest, as illustrating the performances of different telescopes, and as exhibiting the excellencies of the photographic methods. It is known that Professor BOND's catalogue of stars in the nebula required several years' work. It includes nearly every star visible in the Harvard College telescope down to the 15 or 16 magnitude on Professor BOND's scale (which calls a star 17–18 mag., which is 15 magnitude on ARGELANDER's scale).

The following table contains notes of the comparison:

List of some of the stars of BOND's *General Catalogue of Stars in the Nebula of Orion, which have been identified in the photograph of Mr.* ROBERTS.

[Usually no account is taken of stars brighter than 13.0 in BOND's catalogue. BOND's magnitude, 17–18, corresponds to ARGELANDER's 15 magnitude].

STAR.	BOND'S MAG.	
122	10.8	Compare in the photograph 122 (10.8) with 176 (10.8). 122 is very much fainter.
175	13.9	175 (13.9) is about equal to 122 in the photograph.
178	11.5	178 (11.5) is about 14 mag. in the photograph. Compare it with 326 (11.5), 705 (11.5) and with 175 (13.9).
211	13.1	
212	13.1	
[216	13.9]	is not shown in the photograph. It is immersed in nebulosity.
222	13.9	
241	14.8	
260 270	14.2 14.8	These two stars are just visible in the photograph. They are not visible in the L. O. neg. exposed 58^m, but they show in exposures of 100 minutes and upwards.
276	13.1	
283 288	13.9 13.9	In the photograph 288 is considerably brighter than 283.
378	14.8	This star is not shown in Mr. ROBERTS' photograph, as it is immersed in nebulosity. It is about the faintest star shown in Mr. COMMON's print. It is well shown in the L. O. negatives of 60^m exposure. The L. O. negative of 97^m shows a companion-star *s. p.* 378.

380	13.3	
[413	15.0]	I am not sure that this star can be seen in the photograph.
419	14.2	
422	13.9	
434	11.5	434 seems *somewhat* less bright than BOND'S average 11.5 mag. Between 423 and 508 the photograph shows a star 14 + mag. not in BOND. This star just shows in L. O. negative 58^m exposure.
443	13.1	
445	14.8	
478	13.9	There is a star in the photograph closely *s. p.* 478, which is not in BOND'S catalogue. It is not in any of the L. O. negatives up to 97^m exposure.
510	13.1	
511	14.8	
545	13.1	
563	14.4	
566	13.3	
583	11.5	The photograph shows 583 considerably less bright than 11.5. Compare 326, 1051, etc.
587	13.9	
605	13.9	605 and 610 are shown in the photograph as one star. They are shown in the L. O. negatives about $\frac{1}{25}$ of an inch apart, which illustrates one of the advantages of a long focus.
610	14.8	
623	13.9	
644	13.9	
674	14.2	
678	13.9	
680	13.9	
684	14.5	
693	13.9	In the photograph 703 is considerably brighter than 693. It is also slightly brighter in the L. O. negative 58^m exposed, but not so in L. O. negative exposed 97^m. Variable?
703	13.9	
718	13.9	
722	13.3	
749	14.5	
759	15.6	This star is quite bright in the photograph and in some of the L. O. negatives. It is absent or very faint in other L. O. negatives. Variable?
762	13.9	
772	13.9	
[779	15.6]	Not seen in the photograph nor in any of the L. O. negatives.
783	13.9	
786	13.9	In the photograph there is a star 14 + mag. between 786 and 847 not observed by BOND. I do not find it on the L. O. negatives.
787	13.3	
788	13.9	
820	14.2	
[826	14.8]	Does not show in the photograph. It is not seen in L. O. negative exposed 58^m, and just shows in that exposed 97^m.
847	13.1	

865	13.9	
875	14.8	
883	13.3	
888	9.2	is 9.2 and 953 is 9.3 mag., according to BOND, but in the photograph 953 is considerably brighter than 888.
893	13.1	
904	14.2	
912	13.1	
917	13.9	
[929	14.2]	Not seen in the photograph. It does not show in the L. O. negative exposed 58^m, but it is measurable in that exposed 97^m.
936	13.9	
944	14.8	
951	14.8	
953		Between 953 and 1015 are two stars, 14 mag. or less in the photograph, not observed by BOND; these are outside the limits of the L. O. plates.
957	13.9	
[970	14.8]	I am not sure if it is shown in the photograph; just visible in L. O. negative exposed 58^m.
977	13.1	
982	14.2	
999	14.2	The positions in BOND are wrong, but both stars exist and are in the photograph.
1008	13.9	
1011	13.1	These three stars are of the same mag. in BOND, but in the photograph 1029 is much fainter than 1011; 1023 = 1029 in brightness.
1023	13.1	
1029	13.1	
1051	11.5	Between 1015 and 1051 the photograph shows a star 13–14 mag., not in BOND's catalogue. This region is outside of the L. O. negatives.

The general result of the comparison is, that Mr. ROBERTS' print contains substantially all of BOND's stars, and it is probable that the negative shows a considerable number of fainter stars. I find that the Lick Observatory negative exposed 58 minutes, shows practically all the stars of Mr. ROBERTS' print. If there is any advantage, it is on the side of the print. The Lick Observatory negative exposed 97 minutes shows more stars than the print. It is probable that the latter negative and that from which Mr. ROBERTS' print was made, are about equal, as far as showing faint stars is concerned. That is, from 80 to 100 minutes exposure with the 33-inch telescope, will give about the same stars as 205^m exposure with the 20-inch reflector. So far, the advantage is with the large aperture, as it should be, and the advantage would be even more apparent, were it not for the great thickness of the Lick Observatory object-glass. When we come to compare the extent of nebulosity depicted, the advantage becomes enormous in favor of the short-focused reflector. By examining the reproductions of Mr. ROBERTS' negatives of ***Orion*** given in *Knowledge* for May, 1889, page 148, I judge that 15 minutes' exposure with the reflector is about as effective in showing the nebulosity of *Orion* as 60^m with the refractor! If we take a nebula with a continuous spectrum (like the *Andromeda* nebula), and do not use orthochromatic plates, the advantage in favor of the reflector would be still greater. The pregnant remark quoted by Dr. KONKOLY—"Jedes Fernrohr hat seinen Himmel"—is well illustrated by these comparisons, and they point a very practical moral.

The comparison with Mr. COMMON's enlargement shows that his print gives about the same amount of nebulosity in 37^m as is given by the Lick Observatory telescope in 97^m, rather more than less. The faintest star shown by Mr. COMMON's print is probably 378, about 14.8 mag., according to BOND. All of his stars are shown on the Lick Observatory negatives of the shortest exposure (60^m or so), as would be expected. We have so far made no shorter exposures suitable for comparison. When it is considered that this print is an enlargement, the definition appears very fine, and the extent of the nebulosity would probably be even greater, if the picture had been made on the negative plates now in use, which are probably considerably more sensitive than those employed by Mr. COMMON in 1883. An examination of a few negatives lately made at the Lick Observatory gives the following data regarding the performance of the photographic objective ($a = 33$ inches, $f = 570$ inches), on stars.

A negative exposed 81½ minutes on the clusters in *Perseus* shows 202 stars in an area of about $\frac{1}{18}$ of a square degree, in which the Paris picture of 1884 (probably not on the most sensitive plates) exposed 50^m shows 77 stars. A negative of the cluster 20 *Vulpeculæ* exposed 40^m gives everything in Professor SCHULTZ's map, and something more; that is, it shows stars fainter than 13 mag. of BESSEL, probably as faint as, or fainter, than 13 mag. of ARGELANDER. The Potsdam 13-inch photographic refractor gives a 13 mag. star in about 20^m. The star close following the nebula in *Lyra* is a typical 13.2 mag. star.* In 15^m and 20^m exposure this star is just visible, in 30^m it is measurable, in 60^m the star is very plain. In 60^m the nebula itself just begins to make a complete picture with the 33-inch telescope.

* Professor PICKERING has been kind enough to determine the photographic magnitude of this star. In a letter dated December 2, 1890, he writes: "I have had a photograph of the star in *Lyra*, which you mention, taken with an exposure of 20^m in the 8-inch telescope, and a photograph of the Circumpolar Region on the same plate with the same exposure. This enabled the star in *Lyra* to be compared with the three stars Nos. 489, 506 and 543 in Table XI, p. 138 of Vol. XVIII, of the Observatory Annals. The results for the magnitude of the star in *Lyra* were, respectively, 13.2, 13.0, 13.4. It seems therefore to have about the magnitude 13.2 on the scale of Table XI, just mentioned."

PHOTOGRAPH OF THE CLUSTER M. 34 = G. C. 584.

A negative of the cluster M. 34 ($2^h\ 35^m + 42°\ 17'$) was taken on Dec. 14, 1890 in a rather hazy sky with an exposure of 60^m. It has since been compared with the map given by Mr. O. A. L. PIHL in his Monograph (Micrometric examination of Stellar Cluster in *Perseus*. Christiania 1869, 4to.) The general agreement is excellent. There are, however, three cases of obvious disagreement between the negative and the map which it may be worth while to record. It is to be noticed that these cases all refer to the position or magnitude of the smaller stars (10 mag. or less) and that Mr. PIHL gave comparatively little attention to these.* It is therefore probable that the discrepancies referred to are accidental. Still, they are recorded as below.

I. Near the stars nos. 35, 36 Mr. PIHL gives 3 others of about 11 magnitude. In the map the two northernmost of these point very nearly to Star no. 4. In the negative their direction intersects the line 4—1 somewhere near its middle point.

II. In the map there is an 11 mag. star near no. 66, which we will call *a*. The line 66—*a* points (in the map) to Star 24. In the negative there is a faint star 13-14 mag, in the situation of *a*. There is also a star 11 mag. about 17″ further north which is not given in the map.

III. The magnitudes of the small stars on the line 66 to 79 are quite different in the map and in the negative.

I may note a star given in the map at $2^h\ 33^m\ 1^s; + 42°\ 1'$ which the negative shows to be double ($p = 60°$, $s = 3''$ mags. 11–13 estimated.) Mr. PIHL'S observations were made with a small refractor of 3¼ inches aperture. Within the polygon bounded by the lines 69–47–59–68–79–75–69 he has mapped 14 stars, while the negative shows 27. This is a small increase under the circumstances and shows that this cluster is not very rich in the smaller stars.

E. S. H.

MOON-NEGATIVES TAKEN AT THE LICK OBSERVATORY, 1888 AND 1890.

It may be of use to give here a list of the negatives of the Moon taken, up to this time, at the Lick Observatory with the 33-inch photographic lens. It is intended to continue making such plates until a pair of satisfactory negatives has been secured for every few hours of

* See his Memoir, p. 12.

the Moon's age. Two negatives are necessary, in order that any defect in one may be detected by comparing it with another. A full series of such plates will have many uses. Among others is the possibility of determining questions which arise, from time to time, with regard to changes on the Moon's surface, by comparing two negatives taken in the same phase at different epochs. Nothing is said here of direct enlargements of portions of the Moon, as the matter is still in the experimental stage. A number of admirable enlargements from negatives in the focus have also been made in the camera by Mr. BURNHAM, Mr. BARNARD and Mr. CAMPBELL.

During August, 1888, Mr. BURNHAM made a series of 67 experimental Moon-negatives, at my request. Quite a number of these have been given away and some very excellent ones have unfortunately been broken in transmission to and from the observatory. A list of those now at the Lick Observatory is printed below.*

Negatives of the Moon made by S. W. Burnham.

No.	Date, 1888.	Moon's Age.	No.	Date, 1888.	Moon's Age.
?	August 12	5 days	40	August 22	15 days
9	" 13	6 "	43	" 23	16 "
12	" 14	7 "	47	" 24	17 "
14	" 14	7 "	48	" 25	18 "
27	" 16	9 "	51	" 26	19 "
29	" 17	10 "	56	" 27	20 "
33	" 18	11 "	57	" 28	21 "
35	" 20	13 "	61	" 30	23 "
38	" 21	14 "	65	" 31	24 "

No Negatives were taken during 1889. The negatives named in the list which follows have been exposed by myself aided usually by Mr. W. W. CAMPBELL, but often by either Mr. SCHAEBERLE, Mr. KEELER or Mr. A. J. BURNHAM. Nearly all of the negatives taken before September 8, were developed by

* Mr. I. W. TABER (8 Montgomery street, San Francisco) has copies of No. 9 (Moon's Age, 6 days), No. 16 (7 days), No. 20 (8 days), No. 50 (18 days) and is prepared to furnish copies of them.

Mr. CAMPBELL, and all except two, taken since that time, have been developed by Mr. BARNARD. The two referred to have been developed by Mr. BURNHAM. The making of these moon-negatives is, by no means, the principal work of the photographic telescope, but they have been taken as occasion served, and this work will be continued. Copies and duplicates of some of these negatives have been deposited with a few of the principal scientific societies in America and in Europe.

*Negatives of the Moon made in 1890.**

Date, 1890.	Moon's Age.	Date, 1890.	Moon's Age.
*July 20	4 days 3 hours	*Aug. 25	10 days 13 hours
*Nov. 16	4 " 12 "	*July 27	11 " 5 "
July 21	5 " 4 "	*July 27	11 " 6 "
*Nov. 17	5 " 12½ "	*July 28	12 " 3 "
April 24	5 " 20 "	*June 29	12 " 4 "
April 25	6 " 20 "	*July 28	12 " 6 "
*Oct. 20	6 " 23 "	*June 29	12 " 6 "
*Sept. 21	7 " 3 "	*Nov. 24	12 " 15½ "
*Sept. 22	8 " 4 "	Oct. 26	13 " 0 "
April 27	8 " 20 "	*Oct. 26	13 " 1 "
April 27	8 " 21 "	*Oct. 27	14 " 1 "
April 27	8 " 22 "	*Aug. 31	16 " 18 "
*April 27	8 " 23 "	*Aug. 3	18 " 8 "
*Aug. 24	9 " 11 "	*Aug. 4	19 " 8 "
*Aug. 25	10 " 12 "	*Nov. 3	21 " 5 "

* The negatives marked * are in duplicate.

NEGATIVES OF *JUPITER* MADE AT THE LICK OBSERVATORY DURING 1890.

Jupiter was photographed at the Lick Observatory during the last opposition on the dates given in the following tables. The telescope was available for photography on only two nights per week. The negatives give a tolerably complete and an entirely trustworthy history of the planet during the opposition. No change of any special importance could have occurred without quick detection. The work will be continued at the next opposition; and a second series of negatives of longer exposure will probably be taken which will give the four satellites. Such a series will admirably serve to determine the orbits of these bodies.

Negatives of Jupiter in focus have been made on the following dates:

Date, 1890.	P. s. t.	Exposed by	Developed by
July 14	about 12^h	E. S. H. and W. W. C.	E. E. B.
" 21	$12^h\ 0^m$—$12^h\ 9^m$	" " "	W. W. C.
" 27	10 49 —10 54	" " "	"
Aug. 3	11 53 —11 55	" " "	"
" 4	12 13 —12 20	" " "	"
" 10	11 4 —11 10	" " "	"
" 11	—— —11 36	" " "	"
" 18	10 15 —10 20	" " "	"
" 24	9 37 — 9 43	" " "	"
" 25	9 58 —10 2.5	" " "	E. E. B.
Oct. 26	7 20 — 7 28	" " J. E. K.	"
Nov. 3	7 0 — 7 8	" " J. M. S.	S. W. B.

Each negative is on an 8 x 10 plate and contains from 6 to 20 separate images of the planet made with apertures of 33 or 22½ inches with an exposure (usually) of $0^s.13$.

Negatives of Jupiter enlarged in the telescope 8.3 times have been made on the dates and at the times given below.

Date, 1890.	P. s. t.	Exposed by	Developed by
	h m m m m m m		
July 8	13 3 ; 5	E. S. H. and W. W. C.	W. W. C.
" 8	13 11 ; 13	" " "	"
" 8	13 25 ; 27	" " "	"
" 8	13 34 ; 36	" " "	E. E. B.
" 13	13 11 ; 13	" " "	W. W. C.
" 13	13 24 ; 26	" " "	"
Aug. 31	10 24 ; 25	" " "	"
Sept. 1	10 3.5; 4.5	" " "	"
" 8	10 1 ; 9 ; 11	" " J. M. S.	E. E. B.
" 14	9 14 ; 15	" " J. E. K.	"
" 15	8 17.5; 21	" " J. M. S.	"
" 21	8 8 ; 10	" " J. E. K.	"
" 22	7 25 ; 26	" " J. M. S.	"
Oct. 5	7 52 ; 56	" " J. E. K.	"
" 6	7 13 ; 15	" " J. M. S.	"
" 13	7 5 ; 14; 51; 52; 53; 55	" " "	"
" 19	7 17 ; 19; 29; 30	" " J. E. K.	"
" 20	7 45 ; 49	" " J. M. S.	"
" 27	7 8 ; 10	" " "	"
Nov. 2	6 43 ; 45	" " A. J. B.	S. W. B.
" 3	6 36 ; 38	" " "	"

There are usually two images of the planet on each 4 x 5 plate. If the plate is held about 38½ inches from the eye, this position corresponds to a magnifying power of 100; if 7.7 inches to 500. Quite a number of other negatives were made (on the same dates) but the above are those selected for preservation. Nearly a complete set has been presented to the Royal Astronomical Society, and individual negatives have been deposited with various learned societies in America and in Europe. E. S. H.

PREDICTIONS RELATING TO THE ANNULAR ECLIPSE OF THE SUN, JUNE 6, 1891, AND TO THE TRANSIT OF *MERCURY*, MAY 9, 1891.

At the request of Professor HOLDEN I have computed, for the stations tabulated below, the times of the beginning and end of the Annular Eclipse of the Sun, June 6, 1891; and the times of the beginning of the transit of *Mercury*, May 9, 1891.

Pacific Standard Time of the Beginning and End of the Eclipse of June 6, 1891:

PLACE.	Eclipse Begins A. M.	Eclipse Ends A. M.	Duration.
	h m s	h m s	h m s
San Diego, Cal.	6 9 29	7 31 21	1 21 52
Mount Hamilton, Cal.	6 10 8	7 46 44	1 36 36
Prof. Davidson's Observatory, S. F. .	6 10 18	7 48 11	1 37 53
Portland, Oregon.	6 18 38	8 7 52	1 49 14

The times of beginning and end of the eclipse for places within the State of California will, as a rule, fall between the first and last times given in the above table. This eclipse will be visible throughout the greater part of Europe and Siberia and at all points in North America which lie north of an imaginary line drawn through the mouth of the St Lawrence river and the southeast corner of the State of New Mexico.

Transit of Mercury, May 9, 1891.

As the end of the transit occurs after sunset for all points in California, I only give the times of the beginning of the transit. About five minutes after the time of first contact, the planet will be wholly within the disk of the sun.

PLACE.	P. s. t. h	m	1st Contact. s	
San Diego, ...	3	54	3.2	P. M.
Mt. Hamilton, ...	3	54	18.5	"
Prof. Davidson's Observatory, ...	3	54	20.3	"
Portland, Oregon, ...	3	54	40.2	"

The first contact will take place at an angular distance of about 115°.5 from the north point of the sun's limb, the angle being measured towards the east.

J. M. SCHAEBERLE.

LICK OBSERVATORY, January 7, 1891.

SCHMIDT'S DRAWINGS OF NEBULA ORIONIS 1860–75 COMPARED WITH PHOTOGRAPHS.

While I was engaged in observing the nebula of *Orion* at Washington, Dr. SCHMIDT presented me with two beautiful original drawings of the nebula, made by himself, at Athens, with the 6-inch refractor.

The scale of the first is 1 *c.m.* = 1′. It is about 13 inches by 13 inches. The central portions of this drawing are reproduced in *Washington Astronomical Observations* for 1878, Appendix I, page 74, figure 28. No comparison can be given of this drawing with such photographs as those by Mr. COMMON, and at the Lick Observatory, as such a comparison would carry us too much into detail and would require too much space.

The second drawing bears the title "Orion-nebel 1860–75, Athen, J. F. JUL. SCHMIDT." It is about 18 x 18 inches on a scale of 7 *mm* = 8 seconds. It extends from $5^h\ 24^m\ 20^s$ to $5^h\ 32^m\ 52^s$, and from—4°26′ to —6°34′ (1861.0). It was evidently intended by Dr. SCHMIDT to include all the extent that could be seen with his telescope, and it is, in fact, a truly admirable production. I have compared it carefully with Mr. ROBERTS' paper-print, especially as to the outlines of the fainter portions. If it were practicable to reproduce the drawing of Dr. SCHMIDT and the photograph of Mr. ROBERTS here, side by side, very many interesting points could be brought out by comparing the two. As it is not practicable, I have made the comparison by copying with ink on the glass which covers SCHMIDT's drawing, the principal outlines of Mr. ROBERTS' photograph. This could be done very accurately by means of the stars common to both representations. The principal points brought out in this way are as follows: The pictorial effect is vastly more striking and natural in the photograph for all the fainter portions of the nebula. The brighter portions are, of course, all lost in the photograph, as they are necessarily very much over-exposed. (An exposure of 15 to 20 minutes is sufficient for them.) The outlines of the fainter portions given by SCHMIDT are almost exactly the same as those shown by Mr. ROBERTS' paper-print. If, however, the original negative were at hand, the photographic representation would gain still more, for the print, though very excellent, can not do justice to the more delicate details. The drawing shows the latter wonderfully well, but it fails in some respects—notably in the region containing BOND'S stars NOS. 467, 246, 404, etc., where Dr. SCHMIDT has represented the general direction of the fainter wisps of nebulosity not quite correctly. To see them at all was an achievement. They are not given in the fine engraving of G. P. BOND for example. The nebula about *c Orionis* is especially good in SCHMIDT's drawing. The general conclusion from the comparison is that it is *possible* with a six-inch refractor to produce a drawing of the nebula which shall have an astronomical value fairly comparable with that of Mr. ROBERTS' splendid photograph as reproduced in a paper-print. And, moreover, it is evident that SCHMIDT's drawing comes very near to giving all that can be seen with such a telescope. When we reflect, however, on the labor required to produce such a drawing and on the fact that its true value can not even be appreciated until it has been compared with the autographic results of photography, and finally that the 205 minutes of exposure must be set against very many hours spent at the telescope in the years 1860–75, the surpassing importance of such representations as those of Mr. COMMON, of Mr. ROBERTS, and as our own negatives, becomes manifest.

E. S. H.

THE COMETS OF 1890.

The Comets of 1890 have been:

Comet *a*, discovered by Professor BROOKS, at Geneva, New York, March 19.

Comet *b*, discovered by M. J. COGGIA, at Marseilles, July 18.

Comet *c*, discovered by W. F. DENNING, Esq., at Bristol, July 23.

Comet *d*, (D'ARREST's periodic comet) re-discovered by Mr. E. E. BARNARD, at Mt. Hamilton, Oct. 6.

Comet *e*, discovered by Professor T. ZONA, at Palermo, Nov. 15.

Comet *f*, discovered by Dr. R. SPITALER, at Vienna, Nov. 16.

CORRECTIONS TO PUBLICATION NO. 13.

Page 2; *for* MATEO CLARK *read* MATEO CLARK*.
" 8; *for* F. W. ZEILE *read* F. W. ZEILE*.

CORRECTION TO PUBLICATION NO. 14.

Page 11; line 3: *for* Washington *read* Washburn.

SOME PHYSICAL PHENOMENA INVOLVED IN THE MECHANICAL THEORY OF THE CORONA.

By J. M. SCHAEBERLE.

The manuscript of the Report of the Total Solar Eclipse of December 21–22, 1889, has been for some time in the State Printing office, but it is likely that the issue of the Report will be very much delayed, owing to the great amount of work in this office and to the necessity of keeping up with the printing for the State Legislature, now in session.

It, therefore, seems to be worth while to give here a short account of the principles and results of the mechanical theory of the corona as they are presented in the Report in question. A general outline of the theory is printed in the *Publications* A. S. P., vol. II, p. 68. (See also p. 260.) In the unpublished Eclipse Report the subject is treated in the following order:

In § 1, after some introductory remarks, the three fundamental observed facts, on which the whole theory is based, are stated, and certain conclusions drawn from these and other observed facts. Extracts from the works of solar physicists are also quoted.

The three fundamental theorems are:

(1) The eruptions on the sun's surface are most active and numerous in the sun-spot zones.

(2) The sun rotates about an axis passing through its center.

(3) This axis is inclined to the plane of the earth's orbit at an angle of about 82¾°.

In § 2, formulæ are derived which represent the motion of a single particle normally ejected from the surface of the sun from any point within the sun-spot zones (mean latitudes $\pm$ 15°) and other equations which represent the shape of a stream of such particles ejected continuously. The results are tabulated, so as to exhibit the forms of such streams ejected with different initial velocities.

A consideration of these results shows that the observed shapes of the equatorial extensions or wings of the corona can be satisfactorily accounted for by supposing them to be the envelopes of systems of streamers ejected from the sun-spot zones with initial velocities of less than 380 miles per 1^s (such velocities as have been observed in the higher regions of the prominences, for example.)

§ 3 treats especially of the general coronal form as seen in projection from the earth at different times of the year.

In § 4, the fundamental formulæ for the inclination of optical *rays* caused by the superposition of two or more parallel wire screens are deduced; and it is shown that the "polar rays" can be satisfactorily accounted for in this way.

That is, the "polar rays" which we see in any corona, have no objective existence, but are caused by the superpositions of nearly right line streams, one projected upon the other. These right line streams, of which there are a great number, have their bases within the sun-spot zones (some in front, some behind the sun), and in eclipses appear beyond the moon's circumference. They overlap and are seen in perspective projection on the sky, and produce subjective appearances of curved rays, somewhat as the patterns of watered silk are produced. A theory of this projection is given, and it is shown, both mathematically and experimentally, that the curious curvilinear forms of the "polar rays," which are actually observed, can be produced by the perspective overlapping of systems of nearly right line streamers originating within the sun-spot zones.

The same phenomenon takes place in the equatorial extensions or wings, but it is not so marked to the eye, for the reason that we are here looking through a greater depth of streamers, and because there are many more individual streamers concerned in the appearance. The comparison with observation must here be with the *envelope* or exterior boundaries of the wings in general.

§ 5 relates to the change in position of the coronal poles with reference to the poles of the sun, which is due to a change in the heliocentric latitude of the observer.

In § 6, the theoretical trumpet-shaped form of the outer corona is deduced.

In § 7, the subject of *rifts* in the corona is treated.

§ 8 gives the methods for the graphical representations of the "polar rays," with plates in illustration.

In § 9, the theory is compared with all available observations of previous eclipses—whether drawings or photographs. As is to be expected, the general agreement of the photographs with the theory is far more striking (and important) than that of the drawings, which are subject to personal errors, but, even in the case of the drawings, the agreement is most marked and more satisfactory than was anticipated.

§ 10 gives the principal conclusions reached, with the addition of some speculative remarks relating to the solar protuberances, auroras, comets and variable stars. The conclusions may be summarized as below.

All the principal phenomena observed in past solar eclipses can be satisfactorily accounted for and even graphically reproduced according to well known mechanical principles.

Many of the observed details of the corona, which, if regarded as the projections of real forms in space, would be wholly contrary to known laws of motion, are, by this theory, not only demonstrated to be in accordance with rigorous laws, but even the most grotesque of these details can be experimentally reproduced without in any way changing or straining the fundamental facts on which the whole theory rests.

Very suggestive optical phenomena can be produced experimentally by the perspective overlapping of two or more sets of approximately straight and nearly parallel luminous lines, each set of lines making a small angle with the lines of the other sets. For certain positions the slightest shift in the observer's position produces very rapid changes in the positions of the curved rays (or concentric arches) formed. Beyond certain distances only these optical rays can be distinguished, the real luminous lines being lost in the rays.

As a direct outcome of the Mechanical Theory certain physical phenomena result, some of which are here indicated.

(I) All parts of a given unperturbed stream will be in a heliocentric latitude nearly equal to the latitude of the point of ejection.

(II) For a constant ejective force the periodic time t will be the same for all parts of the stream.

(III) The chance of collision of a returning with an outgoing stream varies inversely as the square of the distance of the point of collision, from the sun.

(IV) Near the sun, therefore, collisions must occur which tend to retard or stop the outgoing streams, resulting in a temporary increase in the heat of the combined colliding masses (causing a consequent increase in the brightness of the corona at such places, and at the same time rendering the coronal detail more confused.) This heat will tend to be largely dissipated before such masses fall back into the sun, which they will then reach with comparatively small velocity and low temperature. Unretarded returning streams on striking the sun will tend to greatly raise the temperature at the points of impact; perturbed returning streams could, of course, strike all parts of the sun's surface. Unperturbed returning streams will always fall within the limits of the sun-spot zones.

(V) So long as the incoming streams are very numerous the outgoing ones will, in a great measure, be stopped, so that, after the interval t, there will be comparatively few returning streams; a direct result of this state of things is to allow free passage for the outgoing streams, which, since there are now but few collisions, results in (1) an apparent diminution in the brightness of the corona, (2) more regular and sharply defined detail, and (3) in general a more uniformly illuminated solar surface might be expected, when there are but few or no returning streams. (The periodic character of this intermittent motion can be well illustrated by means of a fine vertical jet of water. The vertical vibratory motion of a light ball, often to be seen in water fountains, is also a good illustration.)

(VI) If the ejective force is such as to make t about five years, a complete cycle of changes will take place in the time $2t$, and after the same manner as is observed in the sun-spot cycle. It is rather remarkable that the aphelion distance of the streams corresponding to this value of t is nearly the same as *Jupiter's* distance from the sun; so that the perturbations produced by this planet may have more to do with the regularity of the period than the assumed constant force of ejection. The initial velocity required to just carry a particle from the sun to *Jupiter* is but little less than a parabolic velocity. For an initial parabolic velocity *Saturn*, alone considered, would, on the same hypothesis, cause a complete cycle of less marked changes in twenty years, *Uranus* in sixty years, and *Neptune* in one hundred and twenty years. The comparatively insignificant planets inside of the orbit of *Jupiter* would cause minor variations, corresponding to cycles, which, even for *Mars*, would be of less than two years duration.

(VII) The chance of the earth passing through one of these outgoing streams, which have a mean latitude of 15° is less than it is for an incoming perturbed stream.

(VIII) A phenomenon similar to the observed zodiacal light would result from the projection of many such streams in space, and the observed extent of this light proves that the matter which causes this illumination extends to greater distances from the sun than the earth's distance.

PREDICTIONS RELATING TO THE ANNULAR ECLIPSE OF THE SUN, JUNE 6, 1891.

The following data, additional to those already given on page 67, may be useful. *Position angle of the points of first and last contact* (counted from N. through E.)

For Mt. Hamilton; *first* 288° 19′; *last* 28° 56′,

For San Francisco; *first* 287° 18′; *last* 30° 16′.

J. M. S.

UNITED STATES NAVAL OBSERVATORY.

From the Report of the Superintendent (Captain F. V. McNAIR, U. S. Navy) for 1890 the following paragraph is extracted:

"PERSONNEL.

"Out of the corps of twelve professors of mathematics in the Navy, there are now only six who are on duty as astronomers; one of the ablest of these will be retired shortly, leaving but five for service at the Observatory and Nautical Almanac Office. * * * The issuing of the annual volumes of the observatory has been for years falling farther and farther behind, until now publication is five years behind the observations, and the amount of work done has been growing less and less. Important improvements in instruments and in methods of observation, as well as new and equally important lines of research, many of which are actively pushed forward at the principal Government observatories, have here been entirely neglected on account of the lack of practical astronomers to make independent observations and to carry on special investigations in conjunction with other observatories. * * *

"From the organization of this naval institution, its personnel must be drawn principally from officers of the Navy; and it is necessary to appoint some professors of mathematics, astronomers of known experience, as it is mainly to this corps that the observatory has to look for aid to keep up its astronomical reputation.

"It is scarcely necessary to add that, when the new Naval Observatory is completed and equipped, the force of astronomers and assistant astronomers will have to be materially increased if the observatory is to be worthy of our great and progressive country."

The Government Observatory ought to be the chief astronomical establishment of the country and equal to any similar institution in the world. For some years past it has been falling behind its true rank, as is pointed out by the Superintendent. A fine observatory building is nearly completed and, in a short time, the instruments will be transferred to their new home. For every reason it is desirable that some change of policy should mark the beginning of the new epoch, and that the observatory should take its legitimate place at the head of astronomical science in America. There is no reason why this cannot be done (nor in fact is there any good reason why it should have lost that position). To take its proper place its astronomical effort must be directed by a competent astronomer.

It is a matter for consideration whether the astronomical head shall be also the official chief or not. One thing is essential and that is, that there shall be one astronomical head and only one, and that he shall have command of sufficient money to insure that the instruments are in perfect working order, that the observations are properly made, quickly reduced, adequately discussed and promptly printed. The chief astronomer will require the aid of four or five heads of departments (The Meridian Service, The Equatorial Service, The Photographic Service, The Magnetic and Meteorological Service, The Computing Bureau) who must be specialists of distinction. These, again, must be assisted by younger astronomers and specialists of ability and of skill, who see such a future before them as will attach them to the service and induce them to give their lives to it. Fifteen or twenty such assistants of various grades will be needed. Such an organization as this will place the observatory where it should be, and no other one will.

It is a source of the deepest satisfaction to all well-wishers of the Naval Observatory that the present Superintendent has expressed so clearly his judgment on this fundamental point. He says "it is mainly to (astronomers of known experience) that the observatory has to look for aid to keep up its astronomical reputation." This is Gospel Truth. There is no other way. If this method is adopted the country will have a central observatory to be proud of. If any of the old timid or temporizing methods are tried once more we shall once more have the unsatisfactory and inadequate results. We shall not only have them, but we shall richly deserve them. The Superintendent can count on the efficient support of the astronomers of the country in his efforts for reform in this direction, and so long as the main principle is kept in view, matters of detail go for little.

EDWARD S. HOLDEN.

Minutes of the Meeting of the Directors, held in San Francisco, at 408 California Street, January 31, 1891.

Vice-President PIERSON presided in the absence of President HOLDEN.

A quorum was present. The minutes of the last meeting were read and approved.

The following fifty-six members were duly elected:

MEMBERS ELECTED JANUARY 31, 1891.*

A. E. ADAMS,	4020 Drexel Boulevard, Chicago, Ill.
H. A. ALLEN,	396 Kenilworth Place, Milwaukee, Wis.
DANIEL APPEL,	62 Holyoke Place, Cleveland, Ohio.
FRAZER ASHHURST,	1830 Spruce Street, Philadelphia, Penn.
CHARLES A. BACON,	Director of the SMITH Observatory, Beloit, Wisconsin.
A. C. BEHR,	Bloomington, Illinois.
Dr. H. H. BELFIELD,	Manual Training School, Chicago, Ill.
F. G. BLINN,	Highland Park, East Oakland, Cal.
Miss HARRIETTA C. BUTLER,	1909 Pine Street, S. F., Cal.
C. O. BORING,	Care J. V. FARWELL & Co., Chicago, Ill.
FRANCIS BRADLEY,	Evanston, Ill.
Mrs. RUTH W. BREWSTER,	145 Oakwood Boulevard, Chicago, Ill.
JOSEPH BROOK,	*Trigonometric Survey, Sydney, New South Wales.*
D. H. BURNHAM,	Rookery Building, Chicago, Ill.
H. P. CARLTON,	716 Nineteeth Street, Oakland, Cal.
Professor C. S. COOK,	Northwestern University, Evanston, Ill.
CHARLES H. CROCKER,	Care H. S. CROCKER & Co., S. F., Cal.
GAYTON A. DOUGLASS,	185 Wabash Avenue, Chicago, Ill.
Captain OLIVER ELDRIDGE,	615 Sutter Street, S. F., Cal.
FERD. ELLERMAN,	5729 Kimbark Avenue, Chicago, Ill.
R. L. J. ELLERY,	*Government Astronomer, Melbourne, Victoria.*
Dr. M. D. EWELL,	97 Clark Street, Chicago, Ill.
Miss JOSEPHINE HARKER,	1909 Pine Street, S. F., Cal.
G. W. HALE,	4545 Drexel Boulevard, Chicago, Ill.
W. E. HALE,	4545 Drexel Boulevard, Chicago, Ill.
ORRIN E. HARMON,	Chehalis, Lewis County, Washington.
Miss CAROLINE C. JACKSON,	1379 Eighth Ave., East Oakland, Cal.
Rev. A. M. LEVEAU,	819 Thirteenth Street, Oakland, Cal.
S. E. HOLDEN,	Napa, California.
E. BURTON HOLMES,	229 Michigan Boulevard, Chicago, Ill.
Professor G. W. HOUGH,	Dearborn Observatory, Evanston, Ill.
A. KEITH,	Riverside, Cal.
Hon. A. KING,	Julian Street, San Josέ, Cal.
(See *Publ.* A. S. P., vol. II, p. 261.)	
Professor GUSTAV C. LUEBEN,	215 Geary Street, S. F., Cal.
WILLIAM S. MOSES,	Supt. Masonic Cemetery, S. F., Cal.
F. S. OSBORNE.	Montauk Block, Chicago, Ill.

A star signifies Life-Membership. Addresses in italics are not within the Universal Posta Union.

RUTHVEN W. PIKE,*	166 Lasalle Street, Chicago, Ill.
NORMAN B. REAM, ...	1901 Prairie Avenue, Chicago, Ill.
EDWARD B. REILLEY, ...	1812 Christian Street, Philadelphia, Pa.
G. W. RITCHEY, ...	5916 Wright Street, Englewood, Ill.
N. A. ROBINSON, ...	Room 1, 430 Kearny St., S. F., Cal.
Dr. H. W. ROGERS, ...	Northwestern University, Evanston, Ill.
Rev. E. H. RUDD, D. D., ...	St. Mary's School, Knoxville, Ill.
FRANK L. SMITH, ...	Oshkosh, Wisconsin.
FRANK M. SMITH, ...	Care D. B. FISK & Co., Chicago, Ill.
H. C. SWAIN, ...	1107 Post Street, S. F., Cal.
J. R. STEWARD, ...	1135 Dunning Street, Chicago, Ill.
I. E. THAYER, ...	204 Front Street, S. F., Cal.
Professor C. B. THWING, ...	Northwestern University, Evanston, Ill.
Professor C. W. TREAT, ...	Observatory, Napa, Cal.
MISS SARA CARR UPTON, . . .	2109 Pennsylvania Avenue, Washington, D. C.
A. W. WAGNER, ...	First National Bank, Joliet, Ill.
E. J. WHITE, ...	*Observatory, Melbourne, Victoria.*
Rev. E. F. WILLIAMS, D. D., . . .	4018 Drexel Boulevard, Chicago, Ill.
Mrs. MARY H. WILLMARTH,* . .	222 Michigan Avenue, Chicago, Ill.
TULLY T. YOUNG, ...	805 Pine Street, S. F., Cal.

AMENDMENT TO THE BY-LAWS.

The following Amendment to the By-Laws was duly adopted by the consenting votes of ten Directors, namely Messrs. ALVORD, BURCKHALTER, GRANT, HILL, HOLDEN, MOLERA, PIERSON, SCHAEBERLE, SOULÉ, ZIEL.

Article XVI (see *Publ.* A. S. P., vol. II, page 36.)

ARTICLE XVI.

In order to increase the usefulness of the Society, any groups of its members residing in the same neighborhood (except in the City and County of San Francisco, State of California) are authorized to form local organizations which shall be known as "The —— Section of the Astronomical Society of the Pacific."

No section shall be formed except by the consent of the Board of Directors of the parent Society.

The proceedings of such sections may be printed in the Publications of the Astronomical Society of the Pacific, either in full or in abstract, and the parent Society shall not be in any way responsible for publications made elsewhere.

No person not a member of this Society in good standing shall be eligible to membership in a section, nor shall membership in a section interfere in any way with the status of the person as a member of this Society.

The special expenses of each section shall be borne by the group of members composing it, and this Society shall not be liable for any debts incurred by any section.

Under the provisions of this Amendment a Chicago Section has effected an organization with the following local officers:

EXECUTIVE COMMITTEE { G. A. DOUGLASS, *Chairman*,
G. E. HALE, *Secretary*,
R. W. PIKE, C. B. THWING, M. D. EWELL.

It was, on motion,

Resolved that the Chicago Section of the Astronomical Society of the Pacific is hereby authorized and duly recognized.

SEAL OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC.

A seal for the Astronomical Society of the Pacific was adopted by the consenting votes of nine Directors as follows: Messrs. ALVORD, BURCKHALTER, GRANT, HOLDEN, MOLERA, PIERSON, SCHAEBERLE, SOULÉ, ZIEL. The thanks of the Directors were voted to W. LEWIS FRASER, Esq., Art-Editor of the *Century Magazine*, for his kindness in superintending the designing of the seal (of which a cut is given in the present number of the Publications.)

The following resolution was adopted:

Resolved that for reasons sufficient to the Directors the annual dues of Professor HIGBIE be remitted until further orders.

The report of the Committee on Life Membership Fund was accepted and the following resolution was adopted as recommended by the Committee:

"*Resolved* that on and after January 1, 1891, all moneys received as life membership fees shall be kept as a separate fund and invested in such interest bearing security or savings bank as may be designated from time to time by the Board of Directors, and only the interest derived from the investment shall be available to defray the running expenses of the Society. Provided, however, that in cases of great exigency, the Board of Directors may, by the unanimous consent of the members thereof, devote the same or a portion thereof, to defray such running expenses, the amount so withdrawn to be repaid as soon as the financial condition of the Society will permit.

"*Resolved* that for the present the San Francisco Savings Union is designated as the bank in which such life membership fees shall be deposited by the Treasurer."

The Committee was discharged.

As required by the Regulations regarding the Comet medal, the following two members of the Astronomical Society of the Pacific were appointed to serve on the Comet-medal Committee for the year 1891: Mr. SCHAEBERLE, Mr. BURCKHALTER.

The following Notice to Members was authorized to be printed in the Publications:

NOTICE TO MEMBERS.

Arrangements have been made by which members can be provided with note paper and envelopes, marked with the seal of the Society, at cost-price, for their correspondence. The stationery must be ordered through the Secretary of the Society in San Francisco and the order must be accompanied by a postal money order (or by United States postage stamps) sufficient to cover the cost, as below:--

For a block of fifty sheets of note paper of good quality, sent by mail, twenty-five cents; for a block of fifty sheets of letter paper, sent by mail, forty cents; for a parcel of 25 envelopes to match the paper, sent by mail, twenty-five cents. The sending must be at the risk of the member.

It was *resolved* that Library tickets issued to members for 1890 be recognized as Library tickets for 1891.

The resignations of the following members were received and accepted: Messrs. CHARLES M. BAKEWELL, WM. IRELAND, J. W. STATELER.

Their names should then be omitted from the list in *Publ.* A. S. P. No. 13.

The meeting then adjourned,

ASTRONOMICAL · SOCIETY · OF · THE · PACIFIC ·

MINUTES OF THE MEETING OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC, HELD IN SAN FRANCISCO, AT 408 CALIFORNIA STREET, JANUARY 31, 1891.

President HOLDEN being absent, Vice-President PIERSON presided.

The minutes of the last meeting were read and approved.

A list of presents was read by the Secretary, and the thanks of the Society voted to the givers.

The Secretary read the names of members duly elected at the meeting of the Directors.

It was announced that a seal had been adopted by the Society.

On motion, the following Committees were appointed by the Chair, to report at the annual meeting, March 28, 1891:

A committee of three—Messrs. F. R. ZIEL, J. H. JOHNSON, A. O. LEUSCHNER—to audit the accounts of the Treasurer.

A committee of five—Messrs. OTTO V. GELDERN, A. J. TREAT, W. A. DEWEY, WARREN B. EWER, W. H. LOWDEN—to nominate a Board of eleven Directors and a Publication Committee of three members and to prepare and print suitable ballots to be voted at the annual meeting. The committee was requested to print the ballots in the same form as at the last election—that is to say, so as to allow *MS.* substitutions to be easily made for the names proposed by them.

The new amendment to the By-Laws, relating to the organization of sections of the A. S. P., was then read, and the organization of the Chicago Section, of 24 members, was announced.

The following papers were announced:

a. The Carleton College Observatory, by the Director, Prof. W. W. PAYNE.

b. The August Meteors, by W. H. S. MONCK, Dublin, Ireland.

c. Corrections to WATSON'S Theoretical Astronomy, by W. W. CAMPBELL, Ann Arbor, Michigan.

d. Notes on Dark Transits of *Jupiter's* Satellites, by JOHN TEBBUTT, Windsor, N. S. W.

Mr. PIERSON read an account of M. JANSSEN'S ascent of Mont Blanc (printed in the present number of the *Publications*), and Mr. KEELER gave an account of his recent spectroscopic observations of the Nebula of *Orion*, which give the motion of the nebula referred to the solar system, and at the same time the normal position of the principal line of nebular spectra. A discussion of the latter subject followed, in which many of the members took part.

MINUTES OF A MEETING HELD NOVEMBER 20, 1890, FOR THE PURPOSE OF ORGANIZING A CHICAGO SECTION OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC.

A meeting, for the purpose of organizing a Chicago Section of the Astronomical Society of the Pacific, was held Thursday evening, November 20, 1890, at 4545 Drexel Boulevard, Chicago. GAYTON A. DOUGLASS was chosen Chairman and GEO. E. HALE Secretary *pro tem.*

The Secretary gave an account of the formation and objects of the A. S. P., and also Professor HOLDEN'S advice in regard to meetings of the Chicago members.

After some discussion, it was moved by Dr. EWELL, and duly seconded, that application for membership in the A. S. P. should be made on condition that a distinct "Chicago Section" be recognized by the parent body. This was put to vote, without debate, and carried.

The question of place of meeting was raised by Mr. SMITH.

A general discussion followed, in which the tower of the South Church was offered by Dr. WILLIAMS, and the Kenwood Observatory by the Secretary. The matter was left to the Executive Committee, to be appointed.

The Chairman and Secretary *pro tem* were elected permanently to these offices, with power to appoint an Executive Committee, to consist of five members, including the Chairman and Secretary.

It was proposed by Dr. EWELL, that the general subject of astronomy be divided into a number of departments, and that members be given the choice of subjects, in order that each may have a special field of work. This suggestion was well received, and left to the Executive Committee.

The programme and time and place of the next meeting were also left to the Executive Committee.

A discussion followed as to an exhibit of astronomical and spectroscopic photographs at the World's Columbian Exposition. It was considered very desirable that such an exhibit be secured, and that this Section take an active part in the matter.

The meeting was then adjourned; after which the spectroscopic laboratories of the Kenwood Observatory were visited, at the invitation of the Secretary. The arc spectrum of iron and the reversal of the sodium lines were shown with the ROWLAND concave grating spectroscope.

The following were appointed on the Executive Committee, to act with the Chairman and Secretary: R. W. PIKE, C. B. THWING and M. D. EWELL.

The following applications for membership in the A. S. P. and in the Chicago Section have been received to date:

RUTHVEN W. PIKE (life member), 166 La Salle St., Chicago.
Professor C. B. THWING, Northwestern University, Evanston, Ill.
FRANK M. SMITH (care D. B. FISK & Co.). Chicago.
GAYTON A. DOUGLASS, 185 Wabash Ave., Chicago.
A. C. BEHR, Bloomington, Ill.
Professor C. S. COOK, Northwestern University, Evanston, Ill.
FERD. ELLERMAN, 5729 Kimbark Ave., Chicago.
Dr. H. W. ROGERS, Northwestern University, Evanston, Ill.
Rev. Dr. E. F. WILLIAMS, 4018 Drexel Boulevard, Chicago.
W. E. HALE, 4545 Drexel Boulevard, Chicago.
G. W. HALE, 4545 Drexel Boulevard, Chicago.
FRANCIS BRADLEY, Evanston, Ill.
Dr. M. D. EWELL, 97 Clark St., Chicago.
Dr. H. H. BELFIELD, Chicago Manual Training School, Chicago.
F. S. OSBORN, Montauk Block, Chicago.
C. O. BORING (care J. V. FARWELL & Co.), Chicago.
D. H. BURNHAM, "Rookery" Building, Chicago.
J. W. ROOT, "Rookery" Building, Chicago.*
NORMAN B. REAM, 1901 Prairie Ave., Chicago,
Professor G. W. HOUGH, Dearborn Observatory, Evanston, Ill.
A. E. ADAMS, 4020 Drexel Boulevard, Chicago.
G. W. RITCHEY, 5916 Wright St., Englewood, Ill.
J. R. STEWART, 1135 Dunning St., Chicago.
GEORGE E. HALE, Kenwood Physical Observatory, Chicago.

GEORGE E. HALE, *Secretary.*

* Died January 15, 1891.

MINUTES OF THE SECOND MEETING OF THE CHICAGO SECTION, A. S. P., JANUARY 2, 1891.

The second meeting of the Chicago Section of the A. S. P. was held January 2, 1891, at the Dearborn Observatory, Evanston, Ill.

Mr. DOUGLASS was in the chair.

The reading of the minutes of the last meeting was dispensed with.

The Secretary announced the receipt of a letter from Professor HOLDEN, stating that an amendment to the Constitution of the A. S. P. was under consideration, which would authorize the formation of Sections of that body.

The Secretary also read extracts from Professor HOLDEN'S address on "The Work of an Astronomical Society," and recommended it to the members. It was voted that copies of this address be obtained, if possible, and distributed among the members.

On motion of Mr. PIKE, an assessment of fifty cents per member was ordered, to meet current expenses of printing, etc. The Secretary was authorized to collect the assessment and to expend it for the purpose indicated.

The Secretary then brought up the question of observing Sections, and strongly advocated their formation. The subject was left under consideratlon until the next meeting.

There being no further business, Professor G. W. HOUGH made some very interesting remarks on observations with small telescopes. Referring to Professor HOLDEN'S paper on "The Work of an Astronomical Society," he stated that it covered the ground very fully, and left little to be said. He recommended the observation of variable stars to those not owning telescopes, as their changes can be very successfully watched with an opera glass, using neighboring stars for comparison.

In the observation of *Jupiter*, and the phenomena of his satellites, much can be done with small glasses, although it is, of course, true that large instruments show the physical features of the planet with more detail. Accurate time can easily be obtained by those who wish to observe the satellites.

In the case of the sun, small telescopes are not much inferior to large ones, as the light is so abundant. Amplification of the image and extremely short exposures are best for photographic work. Photographs of limited areas of the moon's surface, made in the same way, would also be valuable, but in this case the magnification must not be too great, as the light is so much less. There is little trouble from this source, however, when short focus telescopes are used.

At this point a discussion arose as to the use of amplifying lenses, and Mr. SMITH stated his intention of experimenting with an ordinary eye-piece.

Professor HOUGH mentioned the various forms of correcting lenses, and stated his belief that a lens within the focus would prove very satisfactory.

Mr. DOUGLASS remarked that GUNDLACH is now experimenting with this method.

In conclusion, Professor HOUGH spoke of the great opportunities for observing double stars. Out of 6000 known doubles only about 1500 cannot be measured with a five or six-inch glass. These doubles need to be measured from time to time, and a small telescope, with clock and micrometer, is amply sufficient for the great majority. The work of BURNHAM and DEMBOWSKI may be cited as an example.

The instruments of the Observatory were then shown and explained by Professor HOUGH, and a hearty vote of thanks was given him by acclamation.

The meeting then adjourned.

The following have been added to the list of members of the Chicago Section, A. S. P.:

E. BURTON HOLMES, 229 Michigan Boulevard, Chicago.

Mrs. RUTH W. BREWSTER, 145 Oakwood Boulevard, Ghicago.

A. W. WAGNER, First National Bank, Joliet, Ill.

Rev. E. H. RUDD, D. D., St. Mary's School, Knoxville, Ill.

GEORGE E. HALE, *Secretary.*

OFFICERS OF THE SOCIETY.

EDWARD S. HOLDEN (Lick Observatory), - - - - - *President*
WM. M. PIERSON (508 California Street, S. F.), - - }
FRANK SOULÉ (Students' Observatory, Berkeley), - - } *Vice-Presidents*
J. H. WYTHE (Oakland), - - - - - - - - }
CHAS. BURCKHALTER (Chabot Observatory, Oakland), - }
J. M. SCHAEBERLE (Lick Observatory), - - - - - } *Secretaries*
E. J. MOLERA (850 Van Ness Avenue, S. F.), - - - *Treasurer*

Board of Directors—Messrs. ALVORD, BURCKHALTER, GRANT, HILL, HOLDEN, MOLERA, PIERSON, SCHAEBERLE, SOULÉ, WYTHE, ZIEL.

Finance Committee—Messrs. PIERSON, MOLERA, HILL.

Committee on Publication—Messrs. HOLDEN, KEELER, YALE.

Library Committee—Messrs. MOLERA, BURCKHALTER, PIERSON.

Committee on the Comet Medal—Messrs. HOLDEN *(ex-officio)*, SCHAEBERLE, BURCKHALTER.

OFFICERS OF THE CHICAGO SECTION.

Executive Committee—Messrs. DOUGLASS (Chairman), EWELL, HALE (Secretary), PIKE, THWING.

NOTICE.

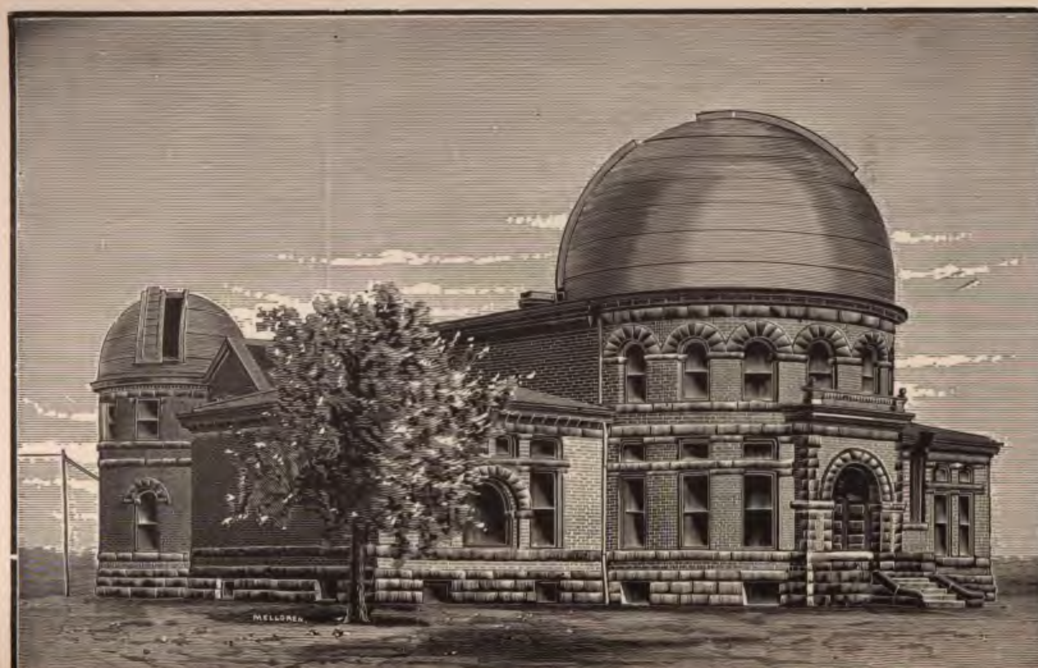
The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year.

It is intended that each member of the Society shall receive a copy of each one of the Publications for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title page and index of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied to members, so far as the stock in hand is sufficient, on the payment of one dollar to either of the Secretaries.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses.

Those members who propose to attend any or all of the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific," at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.



CARLETON COLLEGE OBSERVATORY.

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

VOL. III. SAN FRANCISCO, CALIFORNIA, MARCH 28, 1891. NO. 15.

CARLETON COLLEGE OBSERVATORY.

BY WM. W. PAYNE, DIRECTOR.

The first building used for an Observatory at CARLETON College, was erected in the summer of 1877. It was a wooden structure consisting of a main part, twenty feet square, two stories high, with basement and two wings, each twelve by fifteen feet in size. The west wing was the transit room, in which was a FAUTH 3-inch instrument, and the east wing was devoted to the library and used as a study for the Director.

In the large room on the first floor of the main building were placed the clocks, telegraph instruments, meteorological instruments, chronograph and other minor apparatus belonging to the Observatory. Above this was the circular equatorial room, having a diameter of seventeen feet, in which was mounted the 8-inch CLARK equatorial telescope.

The time of the Observatory has been kept by means of a chronometer by BOND, and two fine HOWARD clocks. The gravity escapement clock and the chronometer are regulated to sidereal time, and the GRAHAM dead-beat is a mean-time clock. The GRAHAM clock is kept on standard time of the 90th meridian, and automatically transmits the daily time-signals to the various railway companies having central offices in Minneapolis and St. Paul. These lines in the aggregate amount to more than 10,000 miles. In the autumn of 1886 the new Observatory building was begun, and October 21, the corner-stone was laid in the presence of a large assembly of people.

The new building was nearly completed and the instruments transferred during the summer of 1887. Both domes were constructed by Messrs. WARNER and SWASEY of Cleveland, Ohio, and are, respectively, seventeen feet and thirty feet in diameter.

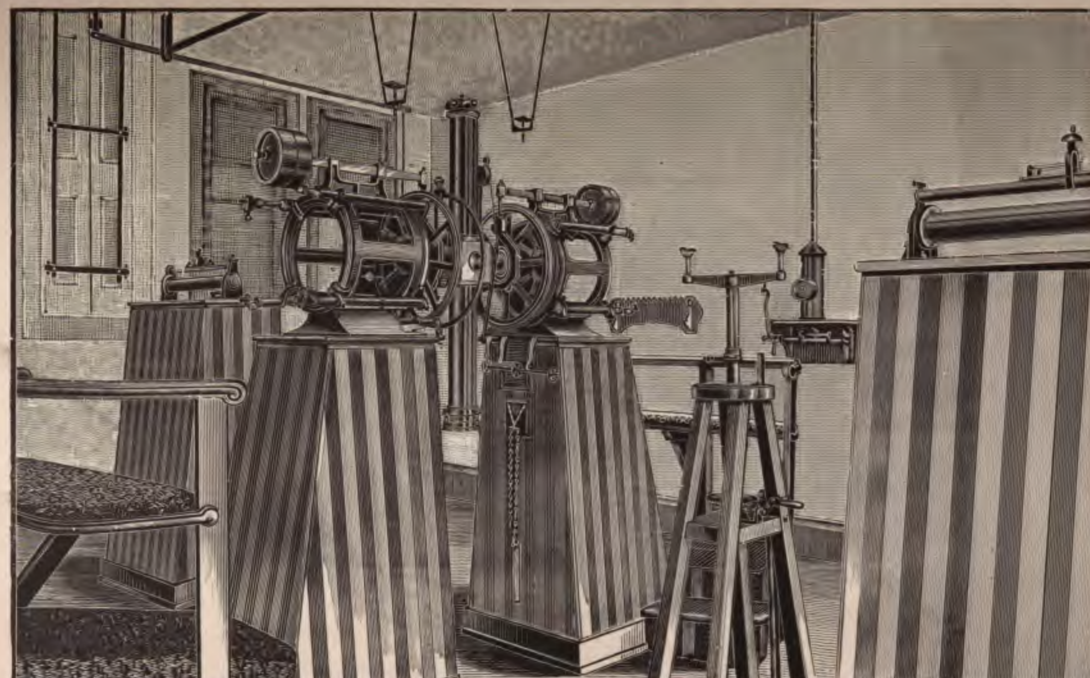
The frontispiece gives a view of the building from the southwest.

From extreme points outside, the structure is 78 feet east and west, and 100 feet north and south. The east wing is the meridian circle room. It is 27 feet and 6 inches north and south, and 22 feet 10 inches east and west and 12 feet between floor and ceiling. The walls of the building are one foot thick, with four windows and transoms on each of the north and south sides. The meridian opening in the roof is 30 inches; on the sides 26 inches.

The meridian circle was made by A. REPSOLD UND SÖHNE, Hamburg, in 1885, and mounted in 1887. Its telescope has a clear aperture of 4.80 inches, and a focal length of 57.5 inches. It is made of three pieces in the ordinary way. The parts of the tube carrying the eye-piece and object-glass are interchangeable. The pivots are 1.44 in. diameter, of steel, and finely polished. The pier-heads are made as the REPSOLDS usually furnish them, with Ys and counterpoising apparatus and microscope holders. The pressure of the pivots in the Ys is about twelve pounds. All piers have a footing in coarse gravel from ten to thirteen feet below the surface of the ground, and are built solid of stone and cement to the first floor. Those of the meridian circle are constructed of brick above the first floor, covered with heavy felt cloth and cased in wood three-fourths of an inch thick.

The meridian circle was a present to the Observatory from JAMES J. HILL, President of the Great Northern Railway, and cost $5000. It has two circles, one graduated to two-minute spaces and the other to degrees only. The dividing is done on a narrow band of silver which is 21.8 inches in diameter and neat, sharp and regular, so that the probable error of a single microscope setting is less than 0".2. Both circles are movable, so that they may be set at any desired nadir reading. Eight microscopes [four for each pier] are provided for reading the circles. The microscope micrometers have screws, two turns of which are equivalent to two minutes on the circle, and the heads of the screws are divided into sixty parts so that the reading is made directly to seconds of arc. This is sufficient to give a general idea of this important instrument.

The central room in the main part of the building, first floor, is semi-circular on the south side. The large equatorial pier is in the middle of the room, surrounded by a case with glass doors and shelves for photographs of astronomical interest, and such other objects as ought to find place in a collection for popular illustration of astronomical themes. This room also contains two HOWARD astronomical clocks encased in the large pier, a BOND chronometer and case, a



REPSOLD MERIDIAN CIRCLE. CARLETON COLLEGE OBSERVATORY.

table of telegraphic instruments to which the lines of the different railroads are run, for the daily time-signals, and a chronograph properly mounted and connected with the two clocks and with all the telescopes belonging to the Observatory.

The west wing is the same size as the east one, and is used for the library and for the study of the Director and that of Dr. H. C. WILSON, his assistant. Shelves for books are arranged on three sides of the room, below which are three tiers of drawers, averaging ten inches deep and about two and a half feet in length. The library now contains 1300 volumes, with some reference books for each of the principal lines of study in mathematics and astronomy. In the north middle room is mounted, in the prime-vertical, a 3-inch FAUTH transit instrument. This instrument is to be used in latitude work for student exercise. In the small dome is placed the CLARK 8¼-inch equatorial telescope. This instrument is provided with an 8¼ photographic corrector and plate-holder, and the instrument does fine work in celestial photography for one of its size. It needs an enlarging eye-piece. The new FAUTH spectroscope adapted to it, which uses either a prism or a ROWLAND grating, greatly enlarges its facilities for instruction or original work.

In a few months the 16-inch equatorial by BRASHEAR and HASTINGS, with mounting by WARNER and SWASEY, will be completed. This instrument is to be provided with a fine, large universal spectroscope by Mr. BRASHEAR. The spectroscope will be provided with a photographic attachment as a means of recording spectra. The clock-work and chronograph attachment to this equatorial are to be the best of their kind. All instruments of the Observatory will be furnished with electric light, and the lecture-room is to be provided with a strong arc light for the study and illustration of various spectra.

A class of three post-graduate students is now in the first term of regular study and work in a course of three years of mathematics and astronomy.

CORRECTIONS TO WATSON'S THEORETICAL ASTRONOMY.

By W. W. CAMPBELL.

I believe that no extensive list of corrections to WATSON'S "*Theoretical Astronomy*" has as yet been published. The following errata have been detected and are communicated to the Society with the hope that they will be useful to those of our members who possess this valuable book. The solutions of the examples in the second and subsequent chapters have not been systematically checked, and probably many of the numerical results are in error. Several of the numerical errata have been detected somewhat at random, and it must not be presumed that the parts of the computations which precede these errors are correct.

In the second column the + and — signs indicate that the numbers of the lines are to be counted from the top and bottom of the page respectively.

Page	Line	*For*	*Read*
22	+ 16	$\frac{m}{a^2}$	$-\frac{m}{a^2}$
22	— 6	$\frac{m_0}{a^2}$	$-\frac{m_0}{a^2}$
27	+ 7	$\frac{dx^2 + dy^2 + dz^2}{dt^2}$	$\frac{dx_{\prime}^2 + dy_{\prime}^2 + dz_{\prime}^2}{dt^2}$
28	— 8	the *areal velocity*	twice the *areal velocity*
29	+ 7	the sum	twice the sum
29	+ 13	" "	" " "
87	+ 11	never exceeds $\pm 0''.9$	seldom exceeds $\pm 1''.0$
93	— 6	never exceed $\pm 0''.9$	seldom exceed $\pm 1''.0$
97	+ 11	$\frac{1}{2}(\Omega - \omega_0)$	$\frac{1}{2}(\Omega' - \omega_0)$
125	+ 19	$\frac{1}{2} q^{\frac{3}{2}} \sec^4 \frac{1}{2} v$	$\frac{1}{2} q^{\frac{3}{2}} \sec^4 \frac{1}{2} v\,dv$
135	— 11	8.668959_n	8.668949_n
135	— 10	9.754919_n	9.754909_n
135	— 5	9.491991_n	9.491994_n
135	— 4	9.950466_n	9.950459_n
135	— 3	7.876553	7.876674
135	— 3	9.222898_n	9.222934_n
138	— 2	$\cdot\frac{dv}{dt}$	$\cdot\frac{dv}{dT}$
139	+ 10	9.242547	9.242559
140	+ 9	$\log\frac{dr}{dq} = 0.186517_n$	$\log\frac{dr}{dq} = 9.241469_n$
140	— 5	+ 0.70855	+ 0.70828
144	+ 6	$x + X_{\prime}$	$x - X_{\prime}$
144	+ 7	$y + Y_{\prime}$	$y - Y_{\prime}$
144	+ 8	$z + Z_{\prime}$	$z - Z_{\prime}$
147	+ 9	$\frac{\varDelta}{r}$	$\frac{r}{\varDelta}$

Page	Line	For	Read
158	+ 10	$\cos(N' + \beta)$	$\sin(N' + \beta)$
172	+ 18	Hence	And
172	− 7	ρ	ρ'
178	− 10	$\frac{rr'' \sin(v'' - v')}{rr' \sin(v' - v)}$	$\frac{r'r'' \sin(v'' - v')}{rr' \sin(v' - v)}$
191	+ 14	(47)	(49)
196	+ 8	$v + \omega''$	$v'' + \omega$
201	+ 3	$\sqrt{\kappa^2 - A^2}$	$\pm \sqrt{\kappa^2 - A^2}$
206	− 11	$\Delta\beta$	$\Delta\beta'$
239	+ 5	$R'R''$ (sin $(\odot'' - \odot')$	$R'R''$ sin $(\odot'' - \odot')$
253	− 10	x	x'
253	− 8	x	x'
254	+ 7	m and l	m' and j'
255	− 1	$(\sqrt{\sigma\sigma''})^3 \log_e \frac{\sigma''}{\sigma}$	$8 (\sqrt{\sigma\sigma''})^3 \log_e \frac{\sigma''}{\sigma}$
259	− 6	$\cos\phi$	$a \cos\phi$
261	+ 12	$v' = u - \omega$	$v' = u' - \omega$
265	+ 9	$-20''.8$	$-20''.2$
265	− 8	$347^\circ\ 0'.4$	$350^\circ\ 35'.1$
265	− 7	$+50^\circ\ 15'.8$	$+5\ 0\ 50'.8$
270	+ 20	10 21 34.19	10 21 34.60
271	− 5	x'	x
282	+ 5	$-x''$	$-y''$
286	+ 1	$x =$	$x' =$
288	− 7	$\frac{1}{1 + P}$	$\frac{1}{1 + P'}$
290	+ 4	$r'r''']$	$[r'r''']$
292	+ 1	ρ'	ρ
292	− 13	t'''	t''
292	− 10	b'''	b''
294	+ 13	$\sin \frac{1}{2} \gamma_0$	$\sin^2 \frac{1}{2} \gamma_0$
299	− 6	first and second	second and third
300	+ 16	$\tan u = \frac{\tan(l' - \Omega')}{\cos i}$	$\tan u' = \frac{\tan(l' - \Omega)}{\cos i}$
301	− 13	β''	β'''
313	− 15	$(98)_4$	$(48)_4$
315	+ 1	$\frac{d\delta}{d\Delta}$	$\frac{d\delta'}{d\Delta}$
315	+ 2	$\frac{d\delta}{d\Delta''}$	$\frac{d\delta'}{d\Delta''}$

Page	Line	For	Read
315	− 4	$(\lambda_2 - \lambda_1') \cos \beta_1'$	$(\lambda_2' - \lambda_1') \cos \beta_1'$
324	+ 17	$-\sin (\lambda - \odot) \cos \beta$	$\sin (\lambda - \odot) \cos \beta$
330	+ 12	$\cos (\alpha - A)$	$\sin (\alpha - A)$
337	− 13	$\frac{d\alpha}{dt}$	$\frac{d\alpha'}{dt}$
337	− 13	$\frac{\alpha'' - \alpha}{t' - t'}$	$\frac{\alpha'' - \alpha'}{t'' - t'}$
337	− 12	$\frac{d\alpha}{dt}$	$\frac{d\alpha'}{dt}$
337	− 11	$\frac{d^2\alpha}{dt^2}$	$\frac{d^2\alpha'}{dt^2}$
339	+ 18	$\frac{\Delta \varDelta}{d \varDelta}$	$\frac{\Delta \varDelta}{\delta \varDelta}$
340	− 1	$2 \sin \frac{1}{2}\epsilon \sin \frac{1}{2}\delta$	$2a \sin \frac{1}{2}\epsilon \sin \frac{1}{2}\delta$
356	+ 15	only the right ascension for the middle place.	for the middle place only the right ascension
356	− 15	$+ n'' (\rho'' \sin \alpha'' - R'' \cos D'' \cos A'')$	$+ n'' (\rho'' \cos \alpha'' - R'' \cos D'' \cos A'')$
357	+ 2	only the right ascension for the middle place.	for the middle place only the right ascension
366	+ 5	$\frac{h}{\sqrt{\pi}} \int_{-\delta}^{+\delta} e^{-h^2\Delta^2} d\varDelta$	$\frac{h}{\sqrt{\pi}} \int_{-\delta}^{+\delta} e^{-h^2\Delta^2} d\varDelta$
382	+ 1	$[ee.2] - \frac{[cc.2]}{[cc.2]}[ce.2]$	$[ee.2] - \frac{[ce.2]}{[cc.2]}[ce.2]$
389	+ 6	*fn* = − 1, and *an*, *bn*, *cn*,	[*fn*] = − 1, and [*an*], [*bn*], [*cn*],
389	− 10	*en*	[*e n*]
392	+ 2	[*cf*. 2]	[*df*. 2]
394	+ 7	*fn*	[*fn*]
398	− 1	[*ee*. 5]	[*ee*. 4]
433	+ 5	ex^4	ϵx^4
434	+ 6	$\beta = -\frac{1}{2\Delta x}(y_2 - y_1 + y_0)$	$\beta = \frac{1}{2\Delta x}(4y_1 - 3y_0 - y_2)$
439	− 13	$\int_{a-i\omega}^{a+i\omega} f(x)\, dx$	$\int_{a-\frac{1}{2}}^{a+i\omega} f(x)\, dx$
441	+ 10	$-f'' (a - \omega)$	$-\frac{1}{2} f'' (a - \omega)$
441	+ 11	$-\frac{1}{2} f'' (a)$	$-\frac{1}{2}{}'' f (a)$
448	− 6	$(x' - x)^2 + (y' - y)^2 + (z' - z)^2$	$(x' - x_0)^2 + (y' - y_0)^2 + (z' - z_0)^2$

Page	Line	For	Read
449	+ 13	$\frac{1}{1047.819}$	$\frac{1}{1047.879}$
451	+ 6	$\frac{d^2\delta x}{dt^2}, \frac{d^2\delta y}{dt^2}, \frac{d^2\delta z}{dt^2}$	$\omega^2\frac{d^2\delta x}{dt^2}, \omega^2\frac{d^2\delta y}{dt^2}, \omega^2\frac{d^2\delta z}{dt^2}$
451	+ 14	" " "	" " "
455	− 14	t	t'
455	− 8	t	t'
455	− 4	$z_{\prime} = z$	$z_{\prime} = z''$
485	− 4	$x_{\prime}$	$z_{\prime}$
485	− 3	$y_{\prime}$	$z_{\prime}$
487	− 3	$y\,d\beta$	$y\,\delta\beta$
492	+ 13	$\frac{d\delta M}{dt^2}$	$\frac{d\delta M}{dt}$
495	+ 16	$(\sin\Omega - h)$	$\sin(\Omega - h)$
503	+ 15	$\frac{d^2\delta z_{\prime}}{dt}$	$\frac{d^2\delta z_{\prime}}{dt^2}$
504	− 5	δN	$\delta N'$
515	+ 6	(192)	(193)
518	− 10	$\frac{2}{r^2}\left[\frac{dr}{dt}\right]$	$-\frac{2}{r^2}\left[\frac{dr}{dt}\right]$
519	− 6	$2pr$	$2r\sqrt{p}$
549	+ 11	direct action of the sun to its disturbing action	disturbing action of the sun to its direct action
649	− 10	$-0''.00000272295\,t$	$-0''.00000272295\,t^2$

Page 36.—The author's statements concerning the permanency of geographical positions should be modified, in view of the results of recent investigations of the latitude problem.

[NOTE.—I would esteem it a very great favor if the readers of this book would inform me of any errata which have escaped my notice].

ANN ARBOR, Mich., 1890, December.

THE FIREBALL IN RAPHAEL'S MADONNA DI FOLIGNO.

BY PROFESSOR H. A. NEWTON.*

In a recent *Notice from the Lick Observatory*,† Director HOLDEN called attention to the fireball which RAPHAEL painted in his picture, the Madonna di Foligno. Any facts relating to such a representation in such a picture cannot fail to be of general interest.

* Yale University, New Haven, Connecticut.

† Publications of the Astronomical Society of the Pacific, vol. ii, p. 19

Among the Italian pictures in the Yale School of Fine Arts is a copy of this painting by TERRY, and the copy is of such excellence that it has been hung in a prominent place in a collection consisting otherwise of original Italian works. In the picture the Virgin is in the clouds, and underneath the clouds is a landscape with buildings. Upon the face of the sky and landscape is a rainbow, so placed as to suggest that the clouds under the Virgin's feet were resting upon the bow. Under the bow is a fireball of a tolerably brilliant red color. It is rounded in front and tapers somewhat behind. Slightly separated from the ball is a long reddish cloud curving back across the sky along the path which the fireball has described. This ball and cloud have sometimes been taken for a bomb and its track. The likeness of the representation to the usual pictures of bright fireballs and their trains, and the want of likeness to a bomb and its train are manifest upon the most casual examination. I feel sure that RAPHAEL did not mean to depict a bombshell.

The introduction of a rainbow in a painting of the Madonna is not unique, and it may safely be assumed that its use is symbolic, and that the bow is not a mere ornament of the landscape. In fact, if this last purpose had been the ruling one, we ought to have had a more natural representation of the rainbow, at least one more natural than that given in the copy. Moreover, since the painter placed a fireball and its train in close connection with the bow, we are naturally led to ask what is the significance of such an unusual addition to the picture?

The picture was painted, it is said, in the year 1511 or 1512, for SIGISMONDO DEI CONTI DA FOLIGNO, private secretary of Pope JULIUS II. In the foreground is the figure of SIGISMONDO kneeling. SIGISMONDO died on the 18th of February, 1512. He had been made *Segretario domestico* to the Pope in 1503, and in his old age is said also to have been made prefect of the *reverenda fabbrica di San Pietro*, to which he bequeathed a considerable fortune. In this office he must have come into relations with RAPHAEL, after the latter came to Rome, in 1508, and shortly before his own death SIGISMONDO ordered the painting of the famous picture. Tradition says that it was made in fulfillment of a vow, but I am not aware of any historic basis for the tradition. It is not improbable that the fireball first suggested the idea that the picture was a votive offering. It is not unlikely, also, that the picture was actually painted after the death of the secretary.

On the 4th of September, 1511, in the second hour of the night, there fell on the banks of the Adda, near Crema, some leagues southeast of Milan, a number of stones. The following are accounts of this fall:

1. From the manuscript diary of a shoemaker, GIOANNI ANDREA DA PRATO, who resided in Milan, AMORETTI* quotes the following entry made contemporary with the stonefall. The manuscript was in the Ambrosian Library in Milan:

"Ma prima che avanti col calamo scorra, dirò siccome il giorno quattro di settembre a ore due di notte, e anche alle sette apparve in aere in Milano un tale splendore di corrente fuoco, che parea refarsi il giorno; e da alcuni entro vi fu veduta una similitudine d'una grossa testa; il che diede alla città gran maraviglia e spavento; e il simile ancora accadette la notte seguente alle nove ore; poi dopo pochi giorni ultra il fiume Adda cascarono dal cielo molte prede (pietre) le quali raccolte furono nel Cremasco de libbre undici, e de libbre octo di colore simile a pietra arsa."

2. BIGOT DE MOROGUES† quotes from Père BONAVENTURE DE SAINT-AMABLE ‡ this account:

"Le 4 septembre, 1511, à Crême, en Lombardie, pendant un orage épouvantable, il tomba dans la plaine des pierres d'une grosseur considérable: six de ces pierres pesoient cent livres. On en porta une à Milan, qui pesoient cent dix livres. Leur odeur étoit semblable à celle du soufre. Des oiseaux furent tués en l'air, des brebis dans les champs, et des poissons dans l'eau."

3. CARDANUS, in a treatise, *De rerum varietate*,§ says:

"Vidimus anno MDX cum cecidissent e coelo lapides circiter MCC in agrum fluvio Abduæ conterminum, ex his unum CXX pondo, alium sexagita delati fuerunt ad reges Gallorum satrapas pro miraculo,, plurimi; colos ferrugineus, durities eximia, odor sulphureus; praecesserat in coelo ignis ingens hora tertia; decidentium lapidum strepitus hora quinta exauditus. Ut mirum sit horis duabus tantam molem in äere sustineri potuisse. Intra viginti menses pulsi Galli. Triennio post reuersi, varia prius fortuna, inde iterum pulsi, ad excidium profligati. Urbs nostra in cujus finibus ciderant lapides, vectigalibus, incendio, fame, obsidione, peste nunquam alias vexata grauius."

* Opusculi Sceltii t. 22, p. 261, note; see also, CHLADNI, Feuer-Meteore, Wien, 1819, p. 210.
† Mémoire historique et physique sur les chutes des Pierres, etc., Orléans, 1812. p. 66.
‡ Annales du Limousin, vol. iii, p. 746.
§ Reprinted in his works. See vol. iii, p. 278; Lyons, 1663.

4. LUBIENIETSKI* quotes from KECKERMANN'S *Syst. Phys.*, 1.6, c. 5, p. 890, as follows:—

"1511. Suessanus Scaligeri praeceptor commemorat, anno 1511, in Lombardia cometam instar ignei pavonis per äera volitasse, e quo, cum evanuisset, tres lapides sulphurei deciderint, horum primus 160 libras, alter 60 libras, tertius 20 libras pondere aequavit."

Several other accounts are quoted, or referred to, by CHLADNI, some of which are apparently repetitions of one or other of the above. CARDANUS wrote his account when he was well advanced in years, and the stonefall occurred when he was ten years old, and living at Pavia, near the place of fall. He is not a careful writer, and his story, instead of being treated as that of an eye-witness, should be looked at as the rehearsal of what CARDANUS had heard people say in his childhood. It well expresses the fears then so common which large meteors and comets caused to men, and the belief that they were omens of terrible significance. His date is evidently in error. We may well question nearly all the details of all the accounts, but that many stones fell and some were carried to Milan and other cities, can hardly be doubted. It is, so far as I know, the only detonating meteor falling in Italy during several years preceding 1512, of which an account has been preserved. I believe that RAPHAEL meant to represent this Crema aerolite in his painting of the Foligno Madonna.

What men thought of such phenomena was shown on the occasion of the fall of the Ensisheim stone nineteen years earlier. This fell near the lines separating the contending French and Imperial forces. MAXIMILIAN, soon after the fall, had the stone brought up to the castle, and he held a council of state to consider what the stonefall meant. SEBASTIAN BRANT, in a poem describing the fall, speaks of the terror it caused to the Burgundians and French. Eleven years later, that is, in 1503, MAXIMILIAN, in a proclamation appealing for aid against the Turks, includes the Ensisheim stonefall among other indications of divine favor. It is natural, therefore, to inquire whether the course of political events in Italy in the latter part of the year 1511 and the earlier part of 1512 were such as to give the Crema stonefall in the minds of men special significance.

In the summer of 1511 the French and their allies were waging war with the Pope and were in possession of Genoa, Ferrara, Milan, and the neighboring regions of Lombardy. They captured Bologna

* Theatrum Cometicum, vol. ii, p. 320.

May 23, 1511. The Pope went to Rome June 27. In July he succeeded in forming a secret league with England, Spain and Venice to attack France. On the 17th of August the Pope was taken seriously ill, became unconscious on the 21st, and recovered consciousness on the 22d. On the 1st of September the schismatic council of Pisa was organized. The Crema stones fell into the French territory September 4th. The league between Spain, Venice and the Pope was published October 5th, and in November England, and subsequently MAXIMILIAN, joined the League. For a time success was with the French. On the 11th of April, 1512, the battle of Ravenna was lost by the papal forces and the Roman territory was seriously threatened. But, in spite of such temporary success, the French were forced to withdraw in June altogether from Milan and northern Italy. What would be more natural to RAPHAEL, under such circumstances, than to unite, in the altarpiece that he was painting, the fireball with the rainbow, in order to symbolize at once Divine reconciliation and assistance?

So far as I know no specimens of the Crema aerolites have been preserved. The accounts say nothing about the direction of motion of the fireball. It seems more probable, however, that the motion was from the south or west than from the north or east. The earth's quit was then about S. 35° W., 15° or 20° high. I have elsewhere shown that aerolites in general follow the earth in its orbit, and this makes a motion of this stone from the S. or W. quite probable. If it was moving from the east of south it would be more strikingly visible in Rome, and its appearance in RAPHAEL's painting may be due to a brilliant course across the Roman skies.

ON THE SIMILARITY OF CERTAIN ORBITS IN THE ZONE OF ASTEROIDS.

BY Professor DANIEL KIRKWOOD, LL. D.

[SECOND PAPER.]

In the *Publications* of the Astronomical Society of the Pacific, No. 7, March, 1890, the present writer named three pairs of minor planets whose orbits are characterized by remarkable similarity. Those given were selected from a larger number, so that only the most marked might first receive the attention of astronomers.

Further study has but strengthened the writer's opinion in regard to the origin of such relations in perturbative action, and the subject is now resumed in the table below:

Groups of Asteroids.

NOTE.—*a* represents the mean distance, *e*, the eccentricity, *i*, the inclination, π, the longitude of the perihelion, and Ω, the longitude of the ascending node.

Groups		*a*	*e*	*i*	π	Ω
				° ′	° ′	° ′
I	84 Clio.	2.3629	0.2360	9 22	339 20	327 28
	115 Thyra.	2.3791	0.1939	11 35	43 2	309 5
	249 Ilse	2.3793	0.2195	9 40	14 16	334 40
II	19 Fortuna	2.4415	0.1594	1 33	31 3	211 27
	79 Eurynome	2.4436	0.1945	4 37	44 22	206 44
III	134 Sophrosyne	2.5647	0.1165	11 36	67 33	346 22
	193 Ambrosia	2.5758	0.2854	11 38	70 52	351 15
IV	37 Fides.	2.6440	0.1758	3 7	66 26	8 21
	66 Maia	2.6454	0.1750	3 6	48 8	8 17
V	218 Bianca	2.6653	0.1155	15 13	230 14	170 50
	204 Callisto	2.6732	0.1752	8 19	257 45	205 40
	246 Asporine	2.6947	0.1050	15 38	256 6	162 35
VI	3 Juno	2.6683	0.2579	13 1	54 50	170 53
	97 Clotho	2.6708	0.2550	11 46	65 32	160 37
VII	203 Pompeia	2.7376	0.0588	3 13	42 51	348 37
	200 Dynamene	2.7379	0.1335	6 56	46 38	325 26
VIII	278 Pauline	2.7575	0.1331	7 50	199 52	62 28
	116 Sirona.	2.7669	0.1433	3 35	152 47	64 26
	1 Ceres	2.7673	0.0763	10 37	149 38	80 47
IX	245 Vera	3.0966	0.1975	5 11	27 48	62 12
	86 Semele	3.1015	0.2193	4 47	29 10	87 45
	106 Dione	3.1670	0.1788	4 38	25 57	63 14
X	121 Hermione	3.4535	0.1255	7 36	357 50	76 46
	87 Sylvia	3.4833	0.0922	10 55	333 48	75 49

Besides the similarity of orbits given in my former paper, I had, in 1887,* specified several others, and in the *Annuaire* for 1891, M. TISSERAND has independently pointed out three cases of decided correspondence. Twenty-four asteroids are included in the foregoing table, and the number will probably increase with future discoveries.

* The *Asteroids*, p. 48.

. The explanation of these facts was referred by the writer to the sun's divellent force.† The disturbing influence of *Jupiter*, however, may alone have been sufficient. The mean density of the solar nebula when its radius was 300,000,000 miles was $\frac{1}{340,000,000}$, the present mean density of the sun being unity. The surface attraction of a primitive or nebulous asteriod was therefore almost *nil*. No exact calculations seem necessary to show that the separated masses might have been dismembered by the unequal attraction of *Jupiter* on the different parts. In other words, this influence was sufficient not only to detach the matter of asteroids from the central body, but also to subdivide the newly-formed nebulous planets until the fragments finally resulted in the existing asteroids. Evidence is not wanting of the actual occurrence of such division in the case of comets.‡ The study is not unworthy the careful attention of astronomers.

ASTRONOMICAL OBSERVATIONS.

Made by TORVALD KÖHL at Odder, Denmark, in the year 1890.

Although the following notes do not claim any importance in regard to the progress of Astronomy, I yet venture to publish these few contributions to our astronomical knowledge in the hope that they, perhaps, will be of some interest to the members of the A. S. P.

January 21, 10^h A. M. (Time of Copenhagen): A group of sun-spots consisting of three larger and some smaller spots is situated near the western limb of the sun's disc.

February 9, 7–9^h P. M.: The *Zodiacal light* appears pretty plain.

Northern limb: $347° + 3°$, $357° + 6°$, $7° + 9°$, $14° + 12°$, $21° + 14°$, $28° + 17°$.

Southern limb: $7° + 19°$, $11° + 9°$, $13° + 0°$, $20° + 6°$, $32° + 13°$.

At 8^h the star *β Ceti* was seen in the southern limb. The summit of the Zodiacal light seems to reach the middle of *Aries*.

Corresponding observations had been projected between Dorset, England, and Odder, Denmark, but the cloudy weather did not favor the undertaking. Nevertheless the Rev. S. J. JOHNSON, M. A.,

---

* The *Asteroids*, p. 48.

† See the *Annuaire* for 1891, p. 301. Compare also the elements of the comets of 1668, 1843, 1880, and 1882.

F. R. A. S., in Dorset, succeeded in making good observations on the 7th, 8th, 9th, 10th, 11th and 17th of February, but on the 9th he has only the following remarks:

"Well seen to-night. I could not perceive any red tint such as has often been mentioned. But it was inferior to the Milky Way, inasmuch as it had none of the *milky* whiteness of the latter."

February 23, *March* 2 and 3: The sun without any spots. On the last day a little facula (German: "Fackel") was seen near the eastern limb.

March 9, $4\frac{1}{2}^h$ P. M.: A little group of three sun-spots is situated in the northwestern part of the sun's disc.

March 15, *April* 1, 3, 4, 5, 6, 7, 8, 9, 14, 20, 27: The sun had no spots on its surface.

April 29, 5^h P. M.: A group of more than fifteen sun-spots is situated in a south heliographic latitude.

April 30, 8^h A. M. and 3 P. M.: The group is now a little more contracted on two places.

At 8^h 30^m P. M.: One hour past sunset the planet *Mercury* is plainly seen with the *naked eye* about three degrees northwards from *Venus* near the horizon in the northwestern sky. Then the planets were observed by aid of the telescope and drawings were made (3-inch telescope, power 168).

May 2, 3, 4: No sun-spots visible.

May 13, 3^h P. M.: In the south part of the sun's surface two spots were perceived.

May 15, 16: No sun-spots.

May 18, 8^h A. M.: A group consisting of three sun-spots is situated on the southern hemisphere.

May 19, 8^h A. M.: The sun-spot has grown less.

May 20, 4^h P. M.: The sun-spot near the sun's limb is exceedingly faint.

May 22, 23, 31, *June* 1: No sun-spots.

June 8, 8^h A. M.: A little sun-spot is situated near the southwestern limb.

June 9, 9^h A. M.: In the place where the spot should be situated, only an exceedingly small black point is now visible, but surrounded with very bright faculæ.

June 10, 12, 14, 15, 16: No sun-spots visible.

June 17: The partial *solar eclipse*. In spite of the cloudy weather, I succeeded in getting a series of drawings of this beautiful phenomenon, which took place here from 9^h 30^m to 11^h 37^m A. M. When the eclipse had reached its maximum, 0.36 of the sun's diameter was covered by the moon. In order to make the eclipse visible to several spectators, the image of the sun was enlarged to the size of one foot in diameter and projected upon a plate of white paper behind the telescope, and thus a number of visitors (about seventy) could witness the interesting sight.

July 5, 8^h A. M.: A group of small sun-spots is seen at the eastern limb.

July 7, 8^h A. M.: A group of three larger and several little spots westwards are visible.

July 9, 8^h A. M.: The group has still not changed very much in general characteristics, but a new circular spot has appeared westwards near the group, and this very dark spot consists apparently only of the umbra and seems to be quite without any penumbra and is so distinct and limited that it has great likeness to a planet (as *Mercury*) on the sun's disc.

July 10, $7\frac{1}{2}^h$ A. M.: While the first group has decreased, the mentioned circular spot has grown larger and has been provided with a narrow penumbra, and in the neighborhood five faint black points are visible, but already at $11\frac{1}{2}^h$ A. M. these points have contracted and formed a greater spot.

July 11, 8^h A. M.: The group has not changed very much since the foregoing day.

July 12, 7^h A. M.: The former chief group is now disappearing, but near the circular spot two smaller spots are visible.

July 13, 7^h A. M.: No great change has taken place in the group of sun-spots.

July 16, 8^h A. M.: No spots. A large facula is situated near the western limb.

July 17, 2^h P. M.: The sun without spots and faculæ.

August 8, 9: No spots. Facula at the northwestern limb.

Observations on Shooting Stars.

No.	Time.	Beginning.	End	Magn.	Notes.
	h. m. s.	° °	° °		
1	August 9, 10 0 45 P.M.	15+51	0+43	2	
2	" 15 30	360+63	315+81	1	
3	" 21 0	16+33	26+33	3	
4	" 38 0	347+20	339+13	2	
5	" 41 0	335+11	339+ 7	3	slow
6	" 45 40	330+15	333+ 7	4	
7	" 49 10	293+16	283+ 8	1	train
8	" 56 15	20+22	52+29	♃	blue, train
9	" 11 8 0	46+40	46+33	2	
10	" 16 45	39+38	35+34	2	
11	" 23 0	353+15	346+ 7	1	train
12	" 27 30	344+22	330+ 7	1	train
13	" 42 45	6+13	2+ 4	3	train
14	" 51.30	7+49	345+33	3	train
15	" 57 50	10+11	4+ 1	2	
16	" 10, 10 42 30	7+49	346+42	3	train
17	" 49 0	2+18	353+ 9	2	train
18	" 57 20	318+28	308+20	3	train
19	" 11 19 40	347+14	341+ 9	3	
20	" 26 30	312÷ 3	303÷15	♃	sparkling train
21	" 32 40	55+40	55+34	1	train
22	" 51 10	8+40	358+29	1	train
23	" 54 45	324÷ 1	318÷10	2	
24	" 56 50	13+ 9	4÷ 2	2	train
25	" 59 10	8+29	19+30	2	train
26	" 12, 10 1 30	310+50	228+66	2	rather slow

The light of the very beautiful blue meteor No. 8 gradually diminished until it reached the middle of its path; then all at once the light was again brighter, but, within a few moments, the meteor was suddenly extinguished. On the 11th and 12th of August cloudy weather troubled the observations.

August 10, 12, 14, 15, 16, 17, 18, 22, 24: No sun-spots.

August 14, 11^h P. M.: A review of *the region near 61 Cygni* was undertaken in regard to the small star No. 15 in the sketch by

October 21, 10½^h A. M.: The group presented a wonderful appearance—an enormous deep black spot, with immense mass of penumbra round it. The sketch shows the appearance of the group at 12½^h P. M. Several small spots have meantime formed in the western part of the group; I specially noticed that two hours earlier the little spot *a* only formed a projection from the penumbra.

October 22, 2½^h P. M.: On this date the group appeared to be most complicated. The western part of it was shaped like a horse-shoe. This immense group presented a spectacle of great solar activity. A little lonely double spot is seen at a distance of half a radius from the large group towards the north.

October 23, 3½^h P. M.: None of the groups has changed very much since yesterday. The horse-shoe-like figure is still present. Eastward of the small group a new little spot has appeared.

October 26, 9½^h A. M.: Great contraction in the large group, so that it is now reduced almost to a single spot; but an enormous spot, consisting of two rows of black umbræ, separated by a tongue of light, stretches through the large spot from north to south. The small group has disappeared; but, instead of it, a new group of small spots has formed northwestward of the large group.

October 27, 10^h A. M.: No great change in the sun-spots since yesterday. There seems to be a tendency to tranquillity in the neighborhood of the groups.

October 28, 9^h A. M.: The last remarks on the groups may be repeated to-day.

October 30, 8½^h A. M.: The sun-spots are now rather near the western limb.

November 13, 10^h A. M.: A little spot is seen in the northwestern part of the sun's disc.

November 16, 17: No sun-spots visible.

November 22, 10^h A. M.: A group of sun-spots is situated quite near the eastern limb.

November 23, 1^h P. M.: The group consists of two separated parts, the eastern with three and the western with two umbræ. Between these spots some masses of penumbra are dispersed.

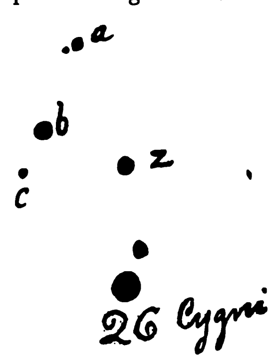
The low latitude of the sun and unfavorable weather rendered it difficult to obtain good solar observations in December.

December 7, 6^h P. M.: *The region near the star 26 Cygni* is reviewed. On the nights of 1887, March 23 and 27 (vide circular L. A. S., No. 16), a red star 7½ magnitude was observed 5^s following

3′ south of 26 *Cygni.* There is no star in DM at this place. The new star shows a spectrum III *Type.* It is Z *Cygni* = Chandler 7192. The place of 26 *Cygni* for 1887 is

$$A\,R = XIX^{h}\ 58^{m}\ 9^{s}$$
$$Decl. = +\ 49^{\circ}\ 46'.9$$

On the 22d April, 1887, I made a sketch of this region and then perceived that the mentioned star *Z* was equal in brightness to the star *b.* With respect to the intensity these stars must be thus ranged: 26, (*b*=*Z*), *a*, *c*.



On the 7th December, 1890, it was found that the star *Z* had decreased, for now the range is: 26, *b*, (*a*=*Z*), *c*.

At the end of the year the star *Z* was difficult to see. On 1891, January 1, 8^{h} P. M., I succeeded in observing the following sequence: 26, *b*, *a*, *c*, *Z*.

Besides the above mentioned observations, a great many reviews of sketches of the fixed stars have been made with reference to supposed variations.

ADDRESS OF THE RETIRING PRESIDENT OF THE SOCIETY, AT THE THIRD ANNUAL MEETING, MARCH 28, 1891.

By Edward S. Holden.

The Society has now been in existence for a little more than two years, and it is, perhaps, not too soon for us to look back over these short years, and to inquire how far we have fulfilled the mission in which we engaged, and especially to inquire what we must look forward to in the future.

Let us first bring together the obvious statistics of our history. On the 7th of February, 1889, a few of us who had been brought into close relations by the observations of the Solar Eclipse of the first of January, determined to form a little club, or society, which should perpetuate those relations, and which should make them fruitful. We began with a membership of 40, nearly all residents of San Francisco or of Santa Clara County. At the annual meeting, a year ago, our membership was 192. After exactly two years' existence we count no less than 360 members (40 life, 320 active). Of the 44 States of the Union, we are represented in:

Arizona	1	Missouri	3
California	220	Nebraska	1
Colorado	1	Nevada	3
Connecticut	3	New Jersey	3
Florida	1	New York	11
Illinois	30	Ohio	3
Iowa	1	Oregon	1
Maine	1	Pennsylvania	7
Maryland	2	Vermont	1
Massachusetts	6	Washington	2
Michigan	4	Wisconsin	3
Minnesota	1	District of Columbia	6
Mississippi	1	New Mexico	1

Our foreign membership has grown amazingly, and it is important to us, not merely numerically, but because a very large proportion of our foreign members are working astronomers—either amateurs or professionals. They are at present distributed as follows:

Africa (C. G. Hope)	1	New South Wales	2
Brazil	2	New Zealand	1
British Columbia	1	Norway	1
China	1	Nova Scotia	1
Denmark	1	Queensland	1
England	14	Scotland	1
France	1	Spain	1
Holland	1	Venezuela	2
Ireland	1	Victoria	2
Mexico	8		

Our publications are regularly sent to observatories and institutions in Albany, Algiers, Amherst, Ann Arbor, Armagh, Berkeley, Berlin, Berne, Bonn, Bordeaux, Brussels, Cambridge (U. S.), Cambridge (Eng.), Capetown, Chicago, Christiania, Cincinnati, Clinton, Cordoba, Dorpat, Dublin, Edinburgh, Fredricksburg, Geneva, Georgetown, Glasgow (Mo.), Glasgow (Scotland), Gotha, Greenwich, Hamburg, Hanover, Helsingfors, Karlsruhe, Kasan, Kiel, Koenigsberg, Kopenhagen, La Plata, Leyden, Leipzig, Lisbon, Liverpool, London, Lund, Lyons, Madison, Madras, Madrid, Marseilles, Melbourne, Menlo Park, Milan, Moscow, Mt. Hamilton, Munich, Naples, Neuchâtel, New Haven, Nice, Northfield, Oakland, Oxford, Palermo, Paris, Parsonstown, Potsdam, Prague, Princeton, Pulkowa, Rio de Janeiro, Rome, San Francisco, Santiago, Stockholm, Strassburg, Sydney, Tacubaya, Tokio, Toulouse, Upsala, University of Virginia, Vienna, Washington, West Point, Williamstown, Zurich.

The Society has lately taken a step which may be of great importance in the way of extending its usefulness. I allude to the formation of local sections. The first of these sections—the Chicago Section of the Astronomical Society of the Pacific—was organized in November, 1890, with a membership of nearly 30 to begin with.

The idea of these local organizations is to allow persons *who are already members of the A. S. P.*, and who live in the same neighborhood, to affect a closer union with each other through frequent meetings and mutual aid, than they could command if their only common bond were the regular reception of our *Publications.*

First and before all, they are members of the A. S. P., and their first loyalty is due to this Society. As members of the Society they desire to co-operate with each other closely, and thus to forward the very objects for which the Society exists. They do this by forming a local group, electing their own officers and making their own rules, paying their own local expenses and following their own plans of research. As they are, first of all, members of the A. S. P., the *Publications* are open to them, of right, whether individually or collectively. Whatever is sent to the parent body may be printed in the journal. And I must emphasize a very important point—the converse—whatever is *not* printed in the journal is entirely informal, and commits the Society in no possible way.

There are certain dangers in this organization, but, with good will, I think they can all be avoided. The parent Society must never seek to interfere with the doings of its members organized in sections, any more than it would interfere with the doings or sayings of an individual member. On the other hand, the several sections must carefully guard themselves from figuring as separate, co-ordinate Societies—but must cherish, first of all, an active loyalty to the parent stem, and regard their local organization simply as a form under which it has been found expedient to utilize their energy.

Our history for the next few years will fully test this new plan. Personally, I am of the opinion that it is not worth while for us to form such groups, unless the groups are tolerably large and likely to be active, as containing skilled observers, whether professionals or amateurs. The Chicago Section will serve as an admirable model, for it is large, and is likely to be larger. It has several observatories, public and private, which are tributary to it, and, best of all, it contains several observers of great skill and experience.

The foregoing simple statistics show eloquently that our Society has, during its brief life, fulfilled its mission so far; or, at least, they show that it is believed to have done so. We may all take a legitimate pride, not only in the number of our members, but also in the remarkable way in which they are scattered over the surface of the globe, from 174° of east longitude to 123° of west, from 59° 54′ of north latitude to 33° 56′ of south, and, I might add, from the sea level up to 4200 feet of altitude, in order to express our distribution in terms of all three co-ordinates.

But mere numbers do not constitute force, and the very scattering of our membership from the Cape of Good Hope to Norway, from Spain to Australia, may prove a source of weakness, and not of strength. It behoves us, then, to look into the future and to see what our duty is, and what we must do to fulfill it. It is the usual way to regard such questions: "What must we *do?*" I would rather put the inquiry in its essence and ask: "What must we *be?*" in order to fulfill our mission; for our doing will follow directly from what we really are.

And here, as in so many other cases, it suffices if we take a clear view of what we are in fact, to enable us to see what we ought to be and must be.

No institution, no body or company of men can permanently flourish unless its members have a sense of corporate loyalty which is fit to master their personalities in matters where the interest of the individual and the interest of the Society or institution may seem to clash. In point of fact, the interest of each individual is apt to be the same as that of the company to which he belongs, and it is usually the highest worldly wisdom to strengthen one's surroundings, even if one has to sacrifice a little self-will. There is somebody who has more wit than anybody—and that is everybody. This trite remark may have no application to the Society at present, but, if it is borne in mind, we shall keep clear of difficulties which lie in the way of all organizations, especially when they become large and powerful—or when they even wish to do so. What, then, *are* we now, as a Society?

Our membership is practically of two kinds: We have Californian members (some 220 in number), and we have non-resident members (some 140).

Our California members are those alone who can be present at our various meetings, whether here in San Francisco or there at Mt. Hamilton. They, alone, have the easy access to our Society rooms, to the Montgomery Library, to any observatory which we may establish in San Francisco. The organization of sections may give to out-of-town members similar advantages in a few cases, but to most of the non-resident members the Society is practically the journal which they regularly receive. It is by their right to contribute to this, and by the expectation that it will contain the information which they are seeking, that alone we hold their loyalty; and it is to the past excellence of the journal that we owe their accession. It is, then, the first duty of all the members to see to it that the *Publications* of the Society are of high quality and thoroughly well supported.

We can make them what we choose, and we should choose to make them such as the whole Society desires and needs. Their scope must be as wide as the interests of the individual members, and their quality should be of the highest. I do not mean by this that we should always write on difficult or obscure problems, but I mean that whatever problem is treated must be treated in the highest spirit, and that no lax work must enter in.

I could illustrate my meaning by pointing out in our *Publications* of the last year several articles, which seem to me to be models of their class; but, without specifying any particular paper, it will be clear to all of us that such admirable work will always be sure to command attention, interest and respect, and to insure that corporate vigor in the Society which reacts on the individual members and gives them what they seek for in association. In all our published writings we should strive to be as simple as practicable, as rigorous as the subject demands, as lucid and clear as it is possible to be, and entirely fearless and fresh. There is room in our journal for every variety of work, from the most technical to the most simple, just as the Society itself contains members who are at the very head of professional astronomy, as well as amateurs of every grade of skill—from those who have spent years in studying special problems at the telescope to others who have never made an observation, whose interest is chiefly in results, and who have no skill in methods. Our *Publications* must meet the desires of all these classes*.

* It may interest you to see the notice which the Royal Society of London has printed at the head of its Philosophical Transactions for more than a hundred years. This notice may well serve as a guide for your Committee on Publication:

* * * * * * "But the Society being of late years greatly enlarged, and their communications more numerous, it was thought advisable that a committee of their members should be appointed to reconsider the papers read before them, and select out of them such as they should judge most proper for publication in the future *Transactions*, which was accordingly

If we are, as I have said, active, alive, modest, competent, we shall have no cause for fear. Our life, as a Society, and our expression of that life in our journal, will be a useful one, though it may not follow any classic pattern.

If we look back over the two volumes of our *Publications*, which are already completed, I think we shall feel that we have found at least the beginning of the way in which we must go.

One of our early dangers was, that the Society being local in name and in membership, might become local in its interests—intense, if you please, but narrow. Its close connection with the Observatory on Mt. Hamilton was both a strength and a danger—a danger of this very sort. I think we are now safe in this respect. Our membership is, as we have seen, widely scattered; but, better than this, the authors of our papers come from all over the world. They even now represent the Society as a whole, not a part of it; and if I should give you a list of the papers which are already promised to us for the next year, you would at once see that they truly represent the Science and the Society at large, and not a mere fraction of it. Our *Publications* for the next year will show this. The *Notices from the Lick Observatory*, which were begun as a mere experiment, seem to have proved themselves useful. They afford the astronomers of the Observatory a prompt and ready means of announcement, and they give the members of the Society a current history of the work which is going on from month to month. They are popular in form, and yet they have contained matter of the first importance, both in their references to original work done at Mt. Hamilton and in their abstracts of such work done elsewhere.

In one respect I confess to a sense of disappointment in the *Notices*. I had hoped that some of them, at least, might be reprinted by the local newspaper press, and serve to supply the need for popular science of which we hear so much. But it appears that they are either overlooked by the editor with the scissors, or that they need another dilution before they can be used in this most useful way.

I must repeat what I said at our last annual meeting, that the members of the Society can help the diffusion of knowledge in no more effective way than by furnishing to the newspapers in their

---

" done upon the 26th of March, 1752. And the grounds of their choice are, and will continue " to be, the importance and singularity of the subjects, or the advantageous manner of treating " them; without pretending to answer for the certainty of the facts, or propriety of the reason- " ings contained in the several papers so published, which must still rest on the credit or judg- " ment of their respective authors."

vicinity abstracts of the work done by the Society, or done by other persons and referred to in our journal.

I think it very important, also, that we should not forget that we are a society of amateurs. The professional members of our body, whether resident or non-resident, will, no doubt, always contribute their full share, or even more than their full share, to our publications. But the government of the Society should always be in the hands of the non-professional members, and, in fact, the Board of Directors has been so constituted in the past, and should be so constituted in the future. You can utilize the professional members for Secretaries, for the Committee on the Comet Medal or on Publication, but the real government and policy of this society of amateurs should remain in the hands of amateurs. I felt so strongly upon this point at our last election that I was very unwilling to serve as President for a second term, and I am coufident that it is necessary to establish the custom of a regular change in your presiding officer. The laborious work of a Society is always done by a few men and I am sure that no member will shrink from labors assigned to him; but the general policy and tendency must be a truly representative one. It will be evident to all of you that your officers of the past year have not shrunk from any work which their duties imposed upon them, since all work is done by volunteers—and I think it only right to say that our Secretaries and Treasurer have done, with only the slightest clerical aid, far more than we could justly have asked of them.

Our relations with other societies are most pleasant in all respects, and for very many reasons. We have no possible rivalries with societies at home or abroad. At home we have our own modest field, and we are cultivating it as well as we know how. Abroad, we can only feel a lively sympathy with the efforts of other bodies like our own.

Both at home and abroad our safeguard is in the motto which we have practically adopted, *to work, and not to compete.*

Young as we are, it is a pleasant thought that we are senior to something! Since the formation of the Astronomical Society of the Pacific a new society has been established on the same broad basis—namely, the British Astronomical Association. Some of our members are also members of the B. A. A., and a number of their founders are members of the A. S. P. likewise.

I am sure that I may, in your name, extend to the new Society our heartiest, best wishes for its success, as well as our thanks to the older societies for the courtesies which we have received at their hands.

There is no better proof of the cordiality of our relations with our correspondents—astronomical societies, observatories and individuals—all over the world, than the list of the gifts which we owe to their kindness. The Catalogue of our Library is a marked evidence of this, and our thanks are due and are extended to all who have contributed to it.

In closing this brief address I think I can fairly say that our Society has more than fulfilled the hopes of its founders. It is already established in useful and important relations, and it depends simply on ourselves—that is, on each one of us—to extend and perfect these relations. Personally, I may be permitted to thank the many members who have contributed, in one way or another, to lightening the work of the officers of the Society, and I am confident that the good will and earnestness which has made my own task pleasant and easy, will support and assist my successor.

THE ASTRONOMICAL OBSERVATORY OF THE UNIVERSITY OF ALABAMA*.

"The astronomical observatory was completed in the summer of 1844. The building was originally fifty-four feet in length by twenty-two in breadth in the center. Fourteen years afterward (in 1858) another apartment, forty feet in length by twenty in width, was added to the east wing. The west wing is occupied by a transit circle, constructed by SIMMS, of London, having a telescope of five feet focal length, with an object-glass of four inches clear aperture. The limb is three feet in diameter, divided in five minutes, and read by four microscopes to single seconds. Accompanying the transit circle is a clock with mercurial compensation, constructed by MOLYNEAUX, of London. The central apartment is surmounted by a revolving dome of eighteen feet internal diameter, under which is placed an equatorial telescope, constructed also by SIMMS, of London. This telescope has a clear aperture of eight inches and a focal length of twelve feet, and is mounted after the manner of the celebrated Dorpat instrument constructed by FRAUENHOFER. It is provided with a parallel line position micrometer, a double-image micrometer, and with a very

* We owe to the courtesy of Dr. W. T. HARRIS, U. S. Commissioner of Education, the permission to print the accompanying plate.

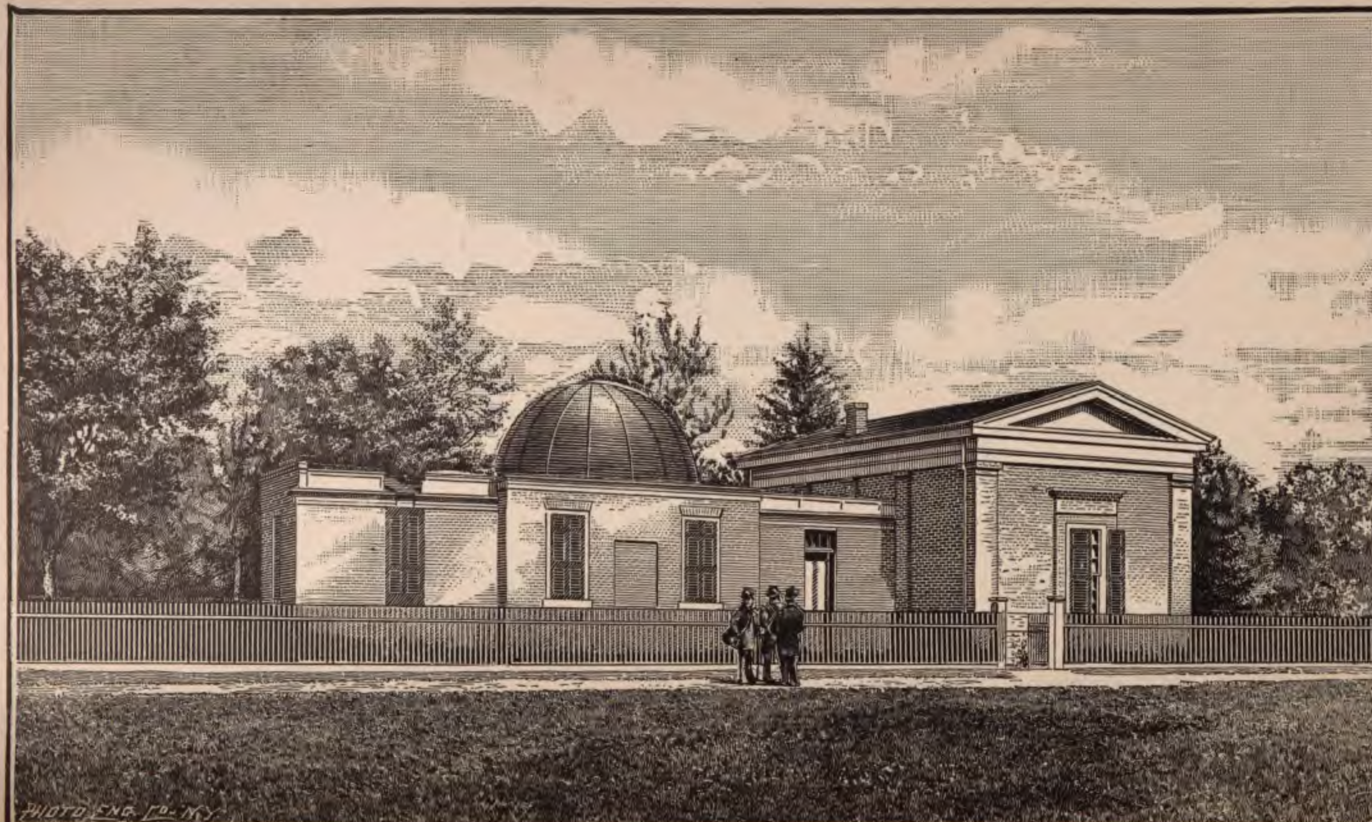


PHOTO-ENG. CO. N.Y.

complete battery of eye-pieces. The hour and declination circles are divided on silver, the former to one second of time, the latter to five seconds of arc, by opposite verniers. In this central apartment is an excellent clock, made by DENT, of London.

There are also two portable achromatic telescopes—one by DOLLAND, of seven feet focal length and four inches aperture, the other by SIMMS, of five feet focal length and three inches aperture—and a reflecting circle by TROUGHTON, of ten inches aperture, read by three verniers to twenty seconds. Portable instruments of smaller size than those above-named increase the facilities for illustrating methods of observation and for instruction in operations in practical astronomy.

The observatory was built and the instruments purchased and mounted under the supervision of the accomplished head of the department, Professor FREDERICK A. P. BARNARD."

—From the History of Education in Alabama, 1889, p. 58.

(FOURTH) AWARD OF THE DONOHOE COMET MEDAL.

The Comet Medal of the Astronomical Society of the Pacific has been awarded to Dr. R. SPITALER, Assistant in the Imperial Observatory of Vienna, for his discovery of a Comet "in the morning hours" of November 16, 1890. The first observation of the Comet was made at $15^h\ 7^m\ 21^s$ G. M. T. This is the first comet discovered by Dr. SPITALER.

(FIFTH) AWARD OF THE DONOHOE COMET MEDAL.

The Comet Medal of the Astronomical Society of the Pacific has been awarded to Professor T. ZONA, Adjunct Astronomer in the Royal Observatory of Palermo, for his discovery of a Comet at $9^h\ 31^m$ G. M. T., November 15, 1890. This is the first comet discovered by Professor ZONA.

The Committee on the Comet Medal,

EDWARD S. HOLDEN,
J. M. SCHAEBERLE,
CHARLES BURCKHALTER.

CORRIGENDA TO VOLUME II.

On page 102, line 14, and on page 103, last line;

$$for \quad f\frac{(a+h)-f(a)}{h}$$

$$read \quad \frac{f(a+h)-f(a)}{h}.$$

On page 177, eighth line from bottom;

for Legendrian *read* Jacobian.

On page 181, for the last three lines substitute the following:

$$\text{hs}\, u = \frac{M_0 M}{2\sqrt{R \cdot OA}} = \frac{M_0 M}{2R}\sqrt{\text{sech}\, 2\phi},$$

$$\text{hc}\, u = -\frac{M_0' M}{2\sqrt{R \cdot OA}} = \frac{M_0' M}{2R}\sqrt{\text{sech}\, 2\phi},$$

$$\text{hd}\, u = \frac{CM}{R+\delta}\sqrt{\text{sech}\, 2(\phi+\phi')}.$$

On page 182, *for* lines 25, 26, 27, substitute the following:

$$\text{sn}\, u = \frac{M_0 P}{2R},$$

$$\text{cn}\, u = \frac{M_0' P}{2R},$$

$$\text{dn}\, u = \frac{CP}{R+\delta}.$$

On page 183, line 23;

for $\text{dn}\, iu = \text{dn}\,(-u) = \text{dn}\, u$

read $\text{dn}\, iu = \text{hd}\,(-u) = \text{hd}\, u.$

On page 187, last line;

for $k \sinh^2 \chi$ *read* $k^2 \sinh^2 \chi.$

IRVING STRINGHAM.

Astronomical Instruments in Course of Construction in the United States [by Fauth & Co].

Washington (D. C.), February 17, 1891.

Mr. Chas. Burckhalter, *Secretary Astronomical Society of the Pacific:*

Dear Sir: If you think it of enough importance for your publications, you may state that we are now engaged on the following astronomical work:

One 20-inch Equatorial with the latest improvements; this instrument will be mounted during the coming summer; it is intended for the Chamberlin Observatory at Denver, Colorado.

One 12-inch Equatorial for the Brown University, Providence, R. I. One 12-inch Equatorial for Georgetown College. These last two will be mounted in about two months.

One 9-inch Equatorial for the Catholic University of America, Washington, D. C.; will be erected as soon as the glass is received; the mounting is all finished.

One 8-inch Equatorial for Napa College, Napa City, California.

One 6-inch Equatorial for Mr. Berger, Pittsburgh.

One 5-inch Equatorial for Boston University.

Several 4-inch Equatorials; one for St. John's University; one for Mexico.

Besides the above we are at work on two meridian circles, several large alt-azimuths, two astronomical transits, six chronographs, astronomical clocks, micrometers, and a large number of engineering instruments. * * * *

Yours truly,

Fauth & Co.
Per G. N. Saegmuller.

THE AUGUST METEORS.

By W. H. S. Monck.

One of the best-known meteor-showers of the year is that which attains its maximum about August 9–11, and has latterly been usually known as the *Perseids*. Since the publication of SCHIAPARELLI'S paper on the subject over 20 years ago, the shower has been supposed to be caused by Comet iii, 1862, the node of whose orbit is reached by the earth on August 10, the cometary radiant being computed at 43° R. A. 57½° N. Decl. by Prof. A. S. HERSCHEL, and at 43°.8 R. A. 57°.2 N. Decl. by Mr. CORRIGAN. Mr. DENNING, indeed, who is probably the best living observer in this department, has made several statements which appear to be inconsistent with the cometary theory, but which have attracted but little attention. The shower, according to him, commences as early as July 8, from a radiant situated at 3° R. A., 49° N. Decl., and terminates about August 22, with a radiant at 78° R. A., 57° N. Decl., there having been a continuous shifting of the radiant during this interval. The high inclination of the comet's orbit to the ecliptic seems inconsistent with the long continuance of the shower, and a few of Mr. DENNING'S figures, which were submitted to the test of computation by Mr. CORRIGAN (in *The Sidereal Messenger*) showed that, if the English observer was correct, the true radiant of the shower must have shifted even more rapidly than the apparent radiant. This is not a very satisfactory state of things, though in the latest English Text-book (CHAMBERS') I find both SCHIAPARELLI'S and DENNING'S theories accepted without comment.

It occurred to me that a historical examination of the facts might tend to clear up some of the difficulties connected with them, but the following sketch is not, of course, intended as a complete one; and, in particular, I do not touch on American observations, because other members of the Society are much more competent to deal with them than I am.

It is only in comparatively recent times that the fact that the meteors in any particular shower usually proceed from a common radiant point has been recognized. Consequently, earlier observations are of very little use, except as showing that there is no agreement in period between that of the comet (computed at 123 years) and the maxima of the meteor-shower. One of the earliest notes that I have met with as to the radiant-point of the August shower is by the late Mr. E. J. LOWE, a very careful observer. Writing to the late Professor BADEN POWELL, who then supplied reports on the subject to the British Association, in 1849, Mr. LOWE says:

"The meteors seen in 1839 diverged from a point situated between *Taurus* and *Pegasus*. Since then the point is stated to be near β *Camelopardalis*. Both last year (1848) and this year (1849), from a great number of observations the point was in, or slightly above, *Casseiopeia*, from the 9th to the 18th of August; but, strange to say, until then this point was not observed. There was another situated in *Cygnus*, which had been plainly discerned since the middle of July. From that time until the 9th of August, if the paths of the meteors were produced backwards, they would nearly all meet at a point situated on the east of α *Cygni*, and on the 10th they were all near the star α. The number of stars seen on the 10th was about 80, the sky being clear for an hour, from shortly before 10 o'clock to near 11 o'clock. Fifty-five of these meteors had their paths and other features recorded here. Out of this number are those noticed proceeding from the direction of these two points of divergence.

From *Cygnus*	23
From *Casseiopeia*	26
Discordant	6
	55

IN 1848.

From *Casseiopeia*	8
From *Cygnus*	5
	13"

The essential point of this letter is that, though there was a fair display of meteors in 1849, none of them came from what may be called the cometary radiant in *Perseus*, and that, in this respect, they agreed with the August meteors previously observed by Mr. LOWE from 1839 onwards.

It was not, indeed, until 1855 that Mr. LOWE noticed *any* August meteors from a radiant in *Perseus*. On the 4th of September in that year he writes to Professor BADEN POWELL:

"On producing the paths of their course backwards, several points of divergence were well-shown on the 9th, 10th, 12th and 13th [of August]. The one most apparent was $\frac{1}{2}°$ above and 2° N. of α *Persei;* the second well-shown was 2° N. of the cluster of stars in the sword-hand of *Perseus;* a third immediately under *Casseiopeia*, and a fourth below χ *Cygni.* The points of divergence in *Casseiopeia* and *Cygnus* were noticed in former years, but the two in *Perseus* were not seen until 1855, and I cannot help thinking that the meteors in other years (that I have observed) did not show these points of divergence in *Perseus.*" And Mr. LOWE proceeds to call the attention of other observers to this fact, but I do not find from Professor BADEN POWELL'S reports that any one claimed to have discovered the radiants in *Perseus* previous to 1855. It will be seen, moreover, that Mr. LOWE speaks of two radiants in *Perseus*, and that neither of them are situated very near the cometary radiant at $43°+57\frac{1}{2}°$. It is not until several years later that I find Mr. LOWE placing the principal radiant of the August shower (for that year) near η *Persei.*

Professor HEIS was pursuing a similar course of observation in Germany about the same time, and somewhat later Dr. SCHMIDT observed this and other showers at Athens. Abstracts of HEIS' and SCHMIDT'S Catalogues are given in the British Association Reports for 1878, but they do not distinguish between the earlier and later observations, which are here important. I find, however, a summary of the observations of both these distinguished astronomers on the August showers in a valuable paper by Colonel (then Captain) TUPMAN, published, I believe, in the year 1872. The results are as follows: 1. Both HEIS and SCHMIDT did not find a single radiant, but a number of distinct radiants. 2. The radiants determined by HEIS do not agree, in position, with those determined by SCHMIDT. 3. Neither HEIS nor SCHMIDT discovered any radiant situated within some degrees of the cometary radiant at $43°+57\frac{1}{2}°$. SCHMIDT, indeed, evidently detected such a radiant at a later period than that to which TUPMAN refers, for in his Catalogue in the British Association Reports for 1878, I find one at $46°+55°$ for the epoch August 3–10. HEIS, however, has still no radiant nearer than $45°+50°$ for the epoch August 1–24.

I ought not to pass over the Catalogue published by the late Mr. R. P. GREG in the British Association Reports for 1868. It is founded, at least in part, on the observations published in these Reports during the preceding 20 years, and it contains a radiant at $44°+56°$ for the period July 28–Aug. 16. Mr. GREG, however, does not give the particulars of the observations from which this radiant was deduced, and it had been found by Mr. LOWE in England, as well as by Italian observers used by SCHIAPARELLI previous to 1868.

The next investigator to whom I shall refer is Colonel TUPMAN, whose observations were made in the Mediterranean in the years 1869, 1870 and 1871. Colonel TUPMAN, like Mr. LOWE, observed that the meteors came from several radiants, which were simultaneously active, and this led him to compare his own observations with those of others, of which he gives a table. From his observations on Aug. 8–10, 1869, he deduced four radiants at 50°+56°, 42°+64°, 50°+63° and 47½°+58°, respectively. On the 11th, besides repeating two of these positions, he obtained a new one at 39°+65°. He then gives a large number of results obtained by others, including those of HEIS and SCHMIDT, already alluded to. Professor PARNISETTI, for Aug. 10–11, 1869, obtained three radiants at 23°+57°, 26°+57° and 61°+43°, respectively. LORENZONI, for almost the same date, obtained three at 26°+62°, 58°+58° and 37°+46°. Neither of these observers seem to have obtained the cometary radiant at all. TACCHINI and DENZA, on the other hand, obtained it, but not alone. TACCHINI obtained an additional radiant at 27°.8+62°, and DENZA an additional radiant at 35°+60°. With regard to the observations of PARNISETTI, LORENZONI and TACCHINI, I may notice that KONKOLY also found a radiant at 24°+59° for the period July 27–Aug. 9, in Hungary. Altogether, TUPMAN's own observations, and the compilation of those of others which he has made, strongly suggest a radiant area of considerable extent, the points of maximum display varying with the conditions of time and place—a conclusion already favored by the observations of Mr. LOWE. TUPMAN's observations, after his return to England, confirmed the theory of distinct centres of activity.

After these observations of Col. TUPMAN, Mr. DENNING of Bristol becomes the most distinguished English observer, though not without many able co-workers. His earlier observations were entirely favorable to the theory of several simultaneous centres of activity, but I cannot say how far he has altered the views which he then expressed, since his adoption of the theory of continuous shifting. On the 10th of August, 1878, he observed two well-marked radiants at 44°+59° and 42½°+54°, respectively. An erroneous computation of the radiant point of Comet i, 1870, which had been published by Prof. A. S. HERSCHEL, led him to ascribe the latter radiant to it, and, to obtain further evidence on the point, he reduced the Italian observations of 1872. The result was the detection of three distinct radiants at 47°+58°, 42°+52° and 33°+57°, respectively. When the error of HERSCHEL's computation was corrected, it appeared that the second of these radiants could have no connection with the comet in question, but its existence was not the less evident. The third radiant, Mr. DENNING's notes, agrees with one already deduced by Prof. HERSCHEL from observations on Aug. 9, 10, 11. "The three positions," he adds, "are each confirmed by stationary meteors. On August 5, 1864, HEIS records one at $44^\circ + 57^\circ$, and on August 9, 1850, at $43^\circ + 53^\circ$, and at Bristol, on Aug. 8, 1876, one was seen at $35^\circ + 57^\circ$." (*Observatory*, vol. ii, p. 165.) Mr. DENNING adds, in the article which I am quoting, that "the diffuse radiation hitherto observed on August 10 is entirely due to the fact of several temporary showers lying near together, about B *Camelopardi*, γ *Persei* and χ *Persei*, supplying meteors of the same visible features in common." This theory of several simultaneous radiants seem, indeed, to be the only alternative to the theory of a radiant area; but it may be doubted whether the several radiants are as accurately defined as we should expect them to be on this supposition. Thus, in this very year, 1878, SCHRADER found a radiant at $32^\circ + 57^\circ$ on the 10th of August. Mr. DENNING repeats his assertion of a number of distinct radiants in simultaneous action in *The Observatory* for the following year (vol. iii, p. 117), and I am not aware how far he still adheres to it. At all events, it is far from resting on his authority alone. To cite one other able observer. On the 4th of August, 1880, Mr. CORDER noted two radiants, one at $35^\circ + 56^\circ$ and the other at $46^\circ + 57^\circ$. He had noticed the former on the 1st of August, and he noticed the latter, without substantial change, on the 6th, 8th, 9th and 11th. The published observations of Mr. DENNING, Mr. BOOTH and others, afford examples of two or more radiants distant from each other by several degrees, having been observed on the same day in this region of the sky. I mention this chiefly because it seems to me to be inconsistent with the continuous shifting of the radiant which Mr. DENNING now advocates. Meteors continue to come to us from points which, according to him, the shifting radiant has passed, and they even come to us from points which, in his opinion, the shifting radiant has not yet reached. For example, he obtained a radiant at $43^\circ + 58^\circ$, on the 31st of July, when the R. A. of his shifting radiant is 10° less than this.

Most of the members of this Society are aware of Mr. DENNING's discovery (for such, I think, it must be called), of stationary, or long-enduring radiants. Meteors come to us from almost the same point in the heavens for months, or even for the whole year, in succession. *Now, it* is worth noticing that the radiant point of the 3d comet of

1862 agrees almost exactly with the position of one of these stationary or long-enduring radiants which sends us meteors (though in diminished numbers) when we are at a great distance from the comet's node. This was almost announced by Mr. DENNING in the year 1887, though his theory of the shifting radiant seems to have afterwards induced him to abandon it. In *The Observatory* (vol. x., p. 299), after describing a shower from 40°+56° in June as "swift, bright streaks, *Perseids*," he adds: "The first of these is new for the epoch, and the position nearly agrees with the great *Perseid* radiant on Aug. 10. There are many additional showers here in the summer and autumnal months; for amongst my previous observations I find the following radiants, which are well confirmed by some other determinations, which I also quote:

Observed at Bristol.		Other Observers.	
Epoch.	Radiant.	Radiant.	Epoch.
1878, July 26–31,	43°+58°		
1879, Aug. 20,	40°+59°	42°+62°,	Aug. 13, Sept. 30 (HEIS)
		42°+55°,	Sept. 5, 1870 (TUPMAN)
1885, Oct. 6–16,	42°+55°		
1877, Oct. 8–14,	43°+58°	47°+56°,	Oct. 3–Nov. 14 (HEIS)
1879, Oct. 14,	48°+60°		
1877, Nov. 4–7	45°+60°	40°+60°,	Nov. 13, 1868 (S and Z)
1885, Dec. 1–10,	44°+55°	45°+56°,	Nov. 23, Dec. 18 (G and H)

I have also seen traces of showers from nearly the same point at other times of the year."

Mr. DENNING'S late Catalogue contains a radiant at 44°+56°, on the 29th of November. In 1879 he determined a radiant at 45°+57°, from 23 meteors, between Aug. 24 and Sept. 14. In *The Observatory* for 1888, when, noting an Italian stationary meteor at 49°+58°, on July 8, he remarks, "which seems to show that there is a shower of *Perseids* more than a month before the August display" (vol. xi., p. 97.) His examination of the Italian observations of 1872 led him to conclude that the activity of the radiant had continued duting the last five months of the year. It will be seen that these figures differ from each other by some degrees, but that is a common feature of all observations on this radiant, and suggests that the true radiant is rather an area than a point. Moreover, the majority of the observations on Aug. 10 indicate for the radiant on that day a R. A. exceeding by about 3° that of the cometary radiant. The declinations agree fairly.

It may, perhaps, be thought that a stationary radiant at 44°+56°

(or thereabouts) is hardly consistent with the theory of a radiant area. But the fact appears to be that other points within this area exhibit the same continued activity. Thus, Mr. DENNING observed a fine shower from a radiant at $32°+53°$, at the end of July, 1878, which he then distinguished from the main *Perseid* shower, but afterwards identified with it. He noticed others at $32°+50°$ on Aug. 14–23, at $33°+54°$ on Sept. 6–9, at $31°+52°$ on Sept. 21–25, and at $32°+50°$ on Oct. 8. HEIS finds one at $31°+55°$ in the month of January, and SCHMIDT finds the same radiant for Aug. 3–12. On the whole, I think the theory of a radiant area is the most probable one, but the evidence at present is hardly sufficient to distinguish between it and the theory of a number of radiant points simultaneously active, some being more prominent than others, in particular years. But neither of these views seem to be reconcilable with the cometary theory as usually understood.

As to Mr. DENNING's theory of the continued shifting of the radiant, though he asserts it very positively, the evidence adduced in its favor seems very weak. There are large gaps in his published observations, and he has himself observed meteors coming from the earlier positions long after the shifting radiant has (according to his theory) passed beyond them. His first position is at $3°+49°$ on July 8. SCHIAPARELLI found a radiant at this precise point on July 31, and Mr. DENNING noticed meteors from very near it to later in July, and again in August. His next position is at $11°+48°$, on July 11, 14. He obtained a radiant at $11°+47°$ from a larger number of similar meteors about three weeks later. His third position is at $19°+51°$, on July 19. HEIS obtained a radiant at $19°+52°$, for August 1–6. Mr. DENNING may have unpublished observations which tend to establish a continuous shifting from $3°+49°$, on the 8th of July, to $78°+57°$ on the 22d of August, but as far as the evidence has been published his case is extremely unsatisfactory—except, perhaps, for three or four days before and after the maximum on Aug. 10.

There is a curious connection between the radiant of these August meteors and that of the November *Andromedes* which are usually traced to BIELA's comet. It will be seen that Mr. DENNING found meteors coming from a radiant at $44°+56°$ on Nov. 29 and Dec. 1, almost contemporaneously with the BIELA shower. He also obtained meteors from substantially the BIELA radiant on August 4–10, and again on Aug. 12–16, during the continuance of the *Perseid* shower. And both showers appear to remain active during the entire period between August and November. Mr. DEN-

NING obtained radiants at 24°+42° on Aug. 20–25, at 28°+45° on Sept. 4–16, and at 25°+44° on Oct. 14, 15. HEIS gives a radiant at 24°+42° for the period Oct. 17–Nov. 23, and Mr. DENNING deduced from Italian observations one at 25°+44° on Feb. 13. It seems to be generally admitted that this BIELA radiant is an area, and that the figures only represent its central point; and it will be noted that, taking 25°+44° for its central point, it is not very remote from the radiant *Perseid* just discussed at 32°+53°. But almost the whole intervening space appears to be covered with radiants, thus throwing the two areas into one. Mr. DENNING observed a BIELA radiant at 29°+46° on the 27th of Nov. He obtained radiants at 30°+46° and 31°+49° in August, and he deduced one at 30°+47° from Italian observations in July. Are such radiants as these three to be classed as *Perseids* or as *Andromedes?* They seem to me rather to show that the two showers are connected together, and that whenever we meet with meteors belonging to the one system, we may look with confidence for those belonging to the other.

To sum up briefly the results at which I have arrived:

1. The August meteors do not come from a single radiant, but from several radiants which are simultaneously active, and some of which are situated at a considerable distance from the cometary radiant.

2. These simultaneous radiants do not occupy the same positions every year or even in the same year, when observations are made at different places, but they are all comprised within an area, which may therefore be regarded as a radiant area.

3. Meteors come from the principal radiant situated at about 44°+56° (and from other points within the radiant area) both before and after the maximum display in August, and the activity of the principal radiant, in fact, lasts from June to December.

4. Meteors come from the radiant area of *Andromeda*, which gives a fine display of meteors about Nov. 27th, simultaneously with the meteors from the radiant area in *Perseus*, and these two radiant areas, in fact, run into each other and cannot be separated.

5. There is no continuous shifting of the radiant; and if the activity of the western portions of the radiant area is more marked during the earlier part of the display, and that of the eastern during its later developments, the activity of the former does not cease when that of the latter becomes conspicuous, but both are simultaneously active.

These features of the display seem to be inconsistent with the cometary theory as usually held. Whether they can be explained by a family of comets (most of them hitherto unobserved) I leave to be considered. The entire subject is well worthy of attention, both by observers and by theorists.

ADDENDUM.

Since writing the foregoing I have examined HEIS' list of meteors observed by him, amounting to over 12,000, published in the year 1877. He refers them to the various radiants determined by himself and others, and gives these determinations for each two consecutive days at the end of July and beginning of August, and for each day when near the 10th. The results may be thus summarized: In no case did the *Perseid* meteors appear to proceed from a single radiant (the usual number being three or four), and the most active radiant was situated near the cometary one only on the two days, Aug. 3 and 4. On these days 27 meteors were traced to a radiant at $47°+56°$, and 5 to a radiant at $44°+57°$, the other active radiants for this date being $18°+50°$ (20 meteors) and $25°+58°$ (11 meteors). On some other days a radiant at $45°+52°$, or $45°+51°$ takes the lead; but on the 10th of August—the date of the maximum display—the principal radiant, according to HEIS, is at $25°+58°$, which is supported by 116 meteors, followed by $11°+60°$ with 80 meteors, $45°+52°$ with 77 meteors and $40°+55°$ with 53 meteors. On the 11th the largest display is again from $25°+58°$, the radiant at $45°+51°$ coming in second, while on the 12th the radiant at $45°+51°$ becomes the most active. I can find no trace of the shifting of the radiant in HEIS' figures. It is curious that the radiant at $25°+58°$, which contributed so largely to former displays, seems to have been almost unnoticed of late years. A radiant at $40°+45°$ is active during most of the period referred to.

GENERAL VIEW OF THE OBSERVATORY OF NICE.

NOTICES FROM THE LICK OBSERVATORY.

PREPARED BY MEMBERS OF THE STAFF.

THE OBSERVATORY OF NICE.*

The accompanying cuts are copied from Lieutenant WINTERHALTER's Report on European Observatories, by the kind permission of the Superintendent of the U. S. Naval Observatory (*See* Publ. A. S. P., vol. III, page 40). The short description here given is condensed from that of Lieutenant WINTERHALTER and from other sources.

The Observatory is situated on the brow of Mt. Gros, an hour's drive from Nice, at an altitude of about 1100 feet above the sea.

The institution has been built and equipped (and is, I believe, maintained) at the expense of M. R. L. BISCHOFFSHEIM, a banker of Paris, who has also made many liberal gifts to other observatories in France. His gifts to the Nice Observatory alone have amounted to something over $1,000,000.

The cut shows the Observatory buildings on the plateau of Mt. Gros. The small house in the left foreground is the pavilion for magnetic observations. The Great Dome for the Equatorial of 30 inches aperture and 59 feet focus is next to this, and the gas-works are directly in the rear. The three buildings on the artificial terrace, faced with stone, in the foreground, are the quarters for the astronomers and the library (in the centre). Next to the Great Dome (of which another full-page cut is given) is the Meridian-Circle House, next to this, the Transit House, and next to this, the Laboratory. The Dome for the 15-inch equatorial comes next. Other buildings are in course of construction, one of which is to contain a heliometer, and another a photographic equatorial.

The Dome rests on a square structure about 87 feet on a side and about 30 feet in height. Within this square structure is a stone

* M. PERROTIN, Director.

cylinder which supports the Dome itself. The Dome weighs about 100 tons and is about 74 feet in diameter (that is, it is of essentially the same dimensions as the Dome at Mount Hamilton). The cost of the metallic part of the Dome was about $40,000 (that of the Lick Observatory, which is of about the same dimensions, was about $53,000). The design is due to M. EIFFEL, who has introduced at least one decided novelty. The Dome can be made to revolve on a live-ring of the GRUBB system (like that at the Lick Observatory) and it can also be raised off the wheels of this live-ring and have its entire weight supported by a hollow metal tank floating in another tank, which is intended to contain a non-freezing mixture. The printed accounts describe the working of this Dome as highly satisfactory. It may be of interest to add here that the Dome at Mount Hamilton has been in constant use since July, 1888, and that not a single night's observation has been lost through any stoppage for repairs or adjustments to the Dome or shutters.

The Nice Observatory is magnificently equipped with equatorials of 30 and 15-inch aperture (objectives by the MM. HENRY of Paris) with a fine meridian circle by MM. BRUNNER frères, etc., etc. It is no part of the plan of this brief note to describe the admirable observations and memoirs which have already come from the Observatory of Nice. A note on the latest volume issued will be found in these *Publications* vol. III, page 45.

The Observatory is, with the exception of that of Pulkowa, the best equipped in Europe; and it should not be forgotton that it is the gift of a single individual, to whom science owes a great debt.

E. S. H.

EXTRACTS FROM LETTERS WRITTEN BY GEORGE P. BOND OF HARVARD COLLEGE OBSERVATORY, 1857-1860.*

SEPTEMBER 28, 1857.

To G. B. AIRY, Astronomer Royal.

* * * * "My father† requests your acceptance of the enclosed plate exhibiting a line photographed by *α Lyræ*, as it passed the field of the equatorial by its diurnal motion, the telescope remaining fixed. You will perceive that your idea for the self-registration of transits and zenith distances can be perfectly realized for this particular star.

"You will notice considerable fluctuations in the intensity and regularity of the line, to be ascribed partly to changes of refraction,

* Kindly communicated by his daughters, Miss ELIZABETH and MISS CATHARINE BOND of Cambridge, Massachusetts.

† *i. e.* Professor WILLIAM CRANCH BOND, then Director H. C. O.

GREAT DOME OF THE OBSERVATORY OF NICE.

partly perhaps to the fact that contiguous portions of the plate are not equally sensitive to the action of light; but it is possible that the phenomenon of *twinkling* may have some part in determining the character of the line traced by the star.

"It seems now highly probable that, by taking advantage of the aids which the art of photography has placed within our reach, a grand impulse might be given to astronomy. By the employment of electro-magnetism the astronomer has been relieved from dependence upon the sense of hearing and the mental faculties which used to be called into exercise in estimating small fractions of time. Photography may be enlisted in aid of, or even as a substitute, for the eye.

"It is to be supposed that these first attempts are susceptible of great improvement. We can certainly have larger telescopes. I believe that a liberal expenditure of money will solve all the mechanical difficulties in the way of constructing a telescope of four times the aperture of ours. We should then photograph *instantaneously* stars $\frac{1}{16}$ as bright as *α Lyræ* and, as I estimate, in less than one minute, stars of the 8th or 9th magnitude, without reckoning upon any improvement in the preparation and treatment of the plates. Certainly we have a right to expect much from chemistry in furtherance of the same end.

"We have also yet to try the effect of using the telescope in a purer atmosphere; on an elevated mountain, for instance."

MARCH 31, 1860.

To J. INGERSOLL BOWDITCH, of Boston.

(In this letter the pressing need of money for the Observatory is forcibly urged, for current expenses, for printing the Annals, etc.)

* * * * * *

"The application of photography to astronomical purposes stands greatly in need of further development. It has already afforded most valuable results, and there is every reason to suppose that it will, one day, become a great power in the investigation of the most interesting problems of astronomy.

"The cost of materials in photographic experiments is one of the principal reasons why the subject has not hitherto been pursued further [here]. It would be certain to repay the outlay if an astronomer of experience, furnished with a good telescope and photographic apparatus, should visit different parts of the world (high table-lands and mountains), and experiment on the advantages of a pure and tranquil atmosphere. It is understood that photography succeeds better in California than here, and better here than in Europe. Now a few essays in California, at an expense of a few thousand dollars, might prove of inestimable advantage to the science.

"The Russian Government has just appropriated nearly $40,000 for an expedition to Persia to try the effect of a pure atmosphere on the visibility of celestial objects, but they make no mention of the most important means of extending our researches, namely, photography. Why should we always have to wait for the example of the Governments of Europe in the encouragement of scientific enterprises? If our observatory had possessed the means, we should have sent off an expedition of this kind, years ago; it was actually proposed, but of course nothing could be accomplished without money. We might now, with equal means, get our expedition to the interior of California, secure the best of results, and get back before the Russians have started."

JUNE, 1859.

To R. C. CARRINGTON, Secretary of the Royal Astronomical Society.

* * * * * *

"I have long thought that there was a kind of sympathy in the photographic action, light acting at one point rendering neighboring points more sensitive, and that possibly a star image slightly out of focus might 'take' quicker than when reduced to a minimum area. If this theory be true, then a poor telescope would be better than a good one, which would be introducing a new principle into practical astronomy!" * * * *

FEBRUARY 29, 1860.

To R. C. CARRINGTON.

* * * "I noticed the unexpectedly rapid action of *Jupiter* in photography on the first occasion that it was taken, nine or ten years ago. On March 22, 1851, I find the following memorandum referring to the time of exposure of the plates. It is noted that it was 'About as long as the moon required, or not much longer.' We have since confirmed this on several occasions, and DE LA RUE comes to much the same conclusion. Within a month or two past, I have engaged Mr. WHIPPLE to photograph the sun, moon and *Jupiter*. The central regions of ☉ and ♃ have decidedly the most intensity, whereas the margins of the moon act first. A photograph of a cannon ball painted white was more uniform in action than either of the three above-named objects, but it most resembled the moon. ARAGO mentions a similar result for flat discs. *Mars* is brightest on the limbs, and *Venus* also; but the latter, not being seen in opposition, does not furnish as safe a comparison as ♂ or ☾. Thus far then,

we find that ♃ and the ☉ rank together in the *distribution* of light on their surfaces.

"Sunlight at ♃ is $\frac{1}{27}$ of the intensity that it is at the earth or the moon, and we should expect, with a similar reflecting surface, that ♃ would show only about $\frac{1}{27}$ of the chemical intensity of the moon, whereas its central parts almost equal the average surface of full moon. (The intensities are in the ratio of 4 to 5, about). So we must suppose ♃ to be either *chemically* self-luminous, or else that it has a very peculiar property of light, reflection affording $\frac{4}{5} \times 27 = 22$ times actinic intensity of moon-light. This may be possible; its surface presented to us is gaseous, the moon is solid.

"The spots, or faculæ, on *Jupiter* remind us of the sun, and it is curious to notice how the discordances in the sun's rotation from proper motion of spots is paralleled in the case of ♃'s rotation, which fluctuates between $9^h\ 50^m$ and $9^h\ 56^m$, a very decided inequality. Then again, the question of the recurrence of spots in the same region is not established, though suspected with both bodies.

"The arrangement of sun-spots in zones and their prevalence in low latitudes, accords with *Jupiter's* belt action.

"I have seen ♃'s bright regions mottled like the sun, and compared the two to each other, years ago. ♃'s spots are sometimes not dusky simply, but *black*, at any rate so-called, though we must not lay too much stress on an expression adopted perhaps hastily. The transit of *Jupiter's* satellites as black spots I have often witnessed. These always enter and pass off *bright*, as seen projected on the margin of the disc. The old explanation, which attributed the appearance to dark spots on the satellites, will not meet the facts, by any means. The first satellite is not black, or even always dark, excepting on a bright zone.

"The grand objection to the idea of *Jupiter's* self-luminosity is the darkness of the shadows cast by the satellites, but it is a question how much defect of light in an object projected on a bright background will cause it to look black, especially when it subtends only a very small angle.

"Perhaps if the side of *Jupiter* turned away from the sun be bright, we ought to see the satellites in eclipse. Here is another difficulty. Then again SEIDEL makes *Jupiter*, *Venus* and *Mars* have equal "Albedo," which militates against the idea that *Jupiter* is any more self-luminous than *Venus*, for instance. I think there must be an error in the monthly notices of the Astronomical Society for January 1860, page 102, as regards the Albedo of *Saturn* and *Mars*.

The latter is fainter than *Saturn*, allowing for distance from sun and areas of illuminated surface.

"I have been looking into the relation between the period of sun-spots and the position of the principal planets as, in case of extensive chemical action going on in their atmospheres a reflex action on the sun, a sympathy between them, might be anticipated. At first all was promising up to 1826, as *Jupiter's* perihelia and aphelia answer tolerably to maxima and minima of spots, but previous to 1826 there is too much divergence. * * * *

"At all events, *Jupiter* should be studied henceforth with special reference to the relation between the physical constitution of its atmosphere and that of the sun."

Grant to the Lick Observatory from the Smithsonian Institution.

The Smithsonian Institution, through its Director, Professor Langley, has granted to the Lick Observatory a sum of money sufficient to provide a portion of the apparatus to be used in making enlargements of the Moon with the photographic object-glass of 33-inches aperture.

Experiments in this direction are already in progress. E. S. H.

Harvard College Observatory Expedition to the Southern Hemisphere.

The following paragraphs from the New York *Herald* give one of the best accounts of this expedition which has so far appeared in print:

"The Harvard Observatory's expedition to Peru is on the eve of setting out—probably the best equipped, as it is to be the most comprehensive, scientific expedition ever sent forth.

"In prosecuting its self-assumed task of making a complete map of the heavens, the observatory has found it necessary to establish branch stations in order that the entire sky may be mapped, and, for this purpose, an astronomical plant has for some time been in operation on Wilson's Peak in Southern California. In May, 1889, a similar station was erected at Chosica, Peru, and there S. I. Bailey and M. H. Bailey, two of Professor Pickering's lieutenants, have been at work systematically observing the southern hemisphere of stars. The observers at Cambridge have done all that they can do in this line—that is, they have located and described all the stars which they can see. The observers at Wilson's Peak have collaborated to the best of their ability, and so have those at Chosica.

"In the latter case, however, climatic conditions have interfered to a very considerable extent, and it has been found necessary to remove the observatory to a point where the cloudy season is at a minimum. Mr. BAILEY made a temporary location in the desert of Atacama, one of the dryest spots of the earth and nearer the coast than Chosica, and it has been concluded to establish a permanent observatory at a point near the city of Arequipa, where an eligible position has been secured at an altitude of about 8000 feet. To this point Professor W. H. PICKERING, accompanied by his family and by Messrs. A. E. DOUGLAS and R. W. VICKARS as assistants, is about to start. The BAILEY brothers will return to Cambridge after the new observatory shall have been established, but the party, which now goes, does not expect to see North America again in six or eight years. By the end of that time Professor PICKERING expects to have mapped the entire southern half of the heavens, which, as is well known, is far richer in bright stars, clusters and nebulæ than the half with which we are familiar. He also will have hitherto unequaled opportunities for observing comets.

"Professor PICKERING also expects to be able to secure photographs of the moon which will be superior to any yet made, and he promises to show me at a date not very far distant a picture of her lunar majesty six feet in diameter. One of the results of the expedition, which will be of the greatest interest, will be the observations of *Mars*, which will be made when the mysterious little planet approaches the earth in August, 1892. *Mars* will then be nearer the earth than since 1872, and far to the south, and this fact, together with Professor PICKERING's altitude and the superb instruments at his command, leads to the expectation that we may be on the eve of remarkable discoveries regarding our very interesting planetary neighbor.

"The location selected is the easiest in the world to reach, for a line of railway leads to it from the coast, and thus the delicate and heavy instruments can be transported with ease and safety to the desired altitude. There are now in Peru, belonging to Harvard University, an 8-inch photographic doublet, a 5-inch visual telescope and an instrument for measuring the brightness of stars. Professor PICKERING is to take with him his unequaled "battery," a 13-inch photographic telescope, with an 8-inch "finder"; a 20-inch reflector, made in England, for photographing faint nebulæ; a 2½-inch camera, mounted equatorially, the instrument which discovered the great spiral in

Orion; a portable transit for determining time, and a seisometer for observing earthquakes. Next year a 12-inch visual telescope will be added to this phenomenal equipment, so that there can be no failure on the ground of lack of instruments.

"There is no wood in the country where the expedition is going, and therefore, a great many things not at all astronomical—a dwelling-house, for example—have to be taken along. The steamer which takes the party will have in her hold even the domes and the iron piers for the telescopes.

"The observatory at Wilson's Peak has been temporarily abandoned."

SPECTROSCOPIC INVESTIGATIONS AT THE JOHNS HOPKINS UNIVERSITY [BY PROFESSOR H. A. ROWLAND].

"The visible and ultra violet solar spectrum has been compared with the spectra of different metals and the position of the metallic lines marked on the spectrum map with the view to identifying as many as possible of the more important lines of the solar spectrum. In this way the spectra of all known metals, with one or two exceptions, have been photographed and compared with that of the sun and its presence or absence in the sun determined. Silicon has thus been found in the sun for the first time. Many important solar lines have also been found to be due to vanadium and scandium. The presence of silver has also been definitely determined. Photographic studies have also been made of the spectra of various chemical preparations of minerals containing rare earths, with the view of isolating the spectra of the various components. This research is yet very incomplete.

"The homologous lines in the spectra of zinc and cadmium have been carefully compared. The so-called 'second spectrum of hydrogen' has been photographed in connection with the sun, and the wave lengths determined, and the spectrum of nitrogen has been photographed and studied in the same way. The various formulæ for the arrangement of lines in band spectra have been tested by means of more accurately determined wave lengths. Investigations have also been made of the effect of heat in modifying the magnetism of iron bars, of the cause of the enormous apparent values of the specific inductive capacity of amyl alcohol and certain other imperfectly insulating liquids. A large number of diffraction gratings have been ruled on the dividing engines for the use of investigators throughout the world. A series of photographic spectra of the metals from wave length 2000 to w. l. 6000 has been obtained, and eye observations made on many of them to the limit of the red rays. These are in conjunction with the solar spectrum, and the original negatives are on about the scale of ANGSTRÖM'S map. The negatives are each nineteen inches long. A micrometer has been constructed measuring wave lengths direct to $\frac{1}{500000}$ part. "During the year there have been eighty-one students in the department of Physics, twenty of whom were graduates."

—From the Annual Report of the President of the Johns Hopkins University (1890).

RECENT IMPORTANT PUBLICATIONS.

Miss AGNES M. CLERKE: The System of the Stars; pp. 424, six plates and many wood cuts.

Dr. J. L. E. DREYER: TYCHO BRAHE—a picture of scientific life and work in the XVI century; pp. 405, five plates and several cuts.

H. H. TURNER and A. A. COMMON: The Companion to the Observatory for 1891. (See *Publications* A. S. P., vol. II, p. 26).

W. T. LYNN: Celestial Motions—a handy book of Astronomy. Sixth edition.

ARTHUR COTTAM: Charts of the Constellations. (Probably the edition in book-form, 12x15 inches, will be found most generally useful to amateurs).

E. W. MAUNDER (Editor): The Journal of the British Astronomical Association (monthly). (Vol. I begins with October, 1890).

J. SCHEINER: Die Spectralanalyse der Gestirne; pp. 474, two plates, seventy-four cuts.

R. VON KÖVESLIGETHY: Grundzüge einer theoretischen Spektralanalyse; pp. 327, plates.

C. E. DUTTON: The Charleston Earthquake of 1886; pp. 185, and many cuts.

A HURRICANE IN AN OBSERVATORY AND WHAT IT DID THERE!

[Extract from *Madras Observations*, vol. 4, 1836-37 by T. G. TAYLOR, pp. 2-3.]*

——"These numbers hold good up to the 30th October, 1836, when the wires were broken—in consequence of the shutters on the roof of the observatory being blown open by the violence of the wind, whereby the instrument was exposed for some minutes to very heavy rain,—having failed during this time to secure the shutter. * * * * I was compelled to take the transit off its axis, and

* This extract was kindly copied for us by WM. C. WINLOCK, Esq., of the Smithsonian Institution. E. S. H.

deposit it in the safest place I could find; the wind which was blowing from the north, had burst open the northern door, as well as the southern one immediately opposite; hence there appeared to be no other choice—than that of placing it upon the table which stood against the most secure part of the northern wall of the Observatory; here, supported by books and a green baize cover, I felt that nothing short of the building falling in, would have in the least degree endangered it; * * * * At this moment the southern doors of the observatory situated opposite to the northern wall where the transit instrument had been deposited—were literally blown to pieces; whereby one of the pieces (about eight feet by six inches by two inches) which had been blown across the room, had fallen edgewise upon the head of the micrometer attached to the transit instrument, and very neatly cut it off, without at all disturbing the other parts of the telescope. Other injuries had been sustained—by the books having been disturbed, whereby the object end of the telescope had fallen upon a pile of books from a height of about two feet, whence two slight indentations had been sustained, one on each side of the tube, at ten or twelve inches above the object end of the telescope; and the tangent screw of the setting circle had been hit; but it was evident that the axis had not in the slightest degree, been injured; a circumstance of which I have since well assured myself from observation. The first fact that struck my notice on examining the instrument was, that the focal length of the object-glass had apparently altered; or rather, that the telescope had become shorter; for, in order to render the principal focus coincident with the wires, it was necessary to remove the object-glass, 07 [*sic*] of an inch from the position it had hitherto occupied in the cell into which it was secured; this remedied (which I was enabled to do by interposing three pieces of brass of this thickness between the bottom of the cell and the frame carrying the object-glass) it only remained that the micrometer screw should be replaced;" * * * *

Artificial Earthquake of January 31, 1891.

On January 30 we learned, through a newspaper paragraph, that on January 31 there was to be an explosion of 3000 lbs. of dynamite in San Francisco, for the purpose of leveling a rocky hill in the suburbs. As it was possible that the shock might be detected at Mt. Hamilton, preparations were made to note the time of its arrival by Mr. Schaeberle, Mr. Barnard and myself. Mr. Schaeberle observed the surface of a basin of quicksilver with the meridian circle, and noted the times of all tremors. Mr. BARNARD directed the 12-inch equatorial on a distant mark, and did the same. I mounted a sensitive level suitably, and watched the variations of its bubble.

Professor GEORGE, at San Jose, kept a lookout on the pen of the Seismometer of the University of the Pacific. The time of the explosion in San Francisco was noted for us by two observers, through the kindness of Hon. GEORGE H. SANDERSON, Mayor of San Francisco, and of J. O'B. GUNN, Esq., of the Union Iron Works. Mr. GUNN's recorded time was $2^h\ 24^m\ 35\frac{1}{8}^s$. The explosive used was, in fact, not *dynamite* at all (as reported) but common black blasting powder, and no shock was noticed, either at San José or Mt. Hamilton. It is possible that this negative result is worth recording.

E. S. H.

MAGNETIC CONSTANTS AT MOUNT HAMILTON.

The following letter is printed by the kind permission of Professor MENDENHALL, Chief of the U. S. Coast and Geodetic Survey. The station referred to is locally known as "The Camp Ground:"

The results of the magnetic observations made on the summit of Mt. Hamton and to the eastward of the Observatory, in latitude 37° 20′ 30″ and in longitude 121° 38′ 16″ W., are as follows:

1888. Oct. 28, 29, 30. Declination 15° 50′.4 East
" " " Dip 61° 52′.1
Horizontal intensity 5.580 English Units, or 0.2573 dyne.
Total intensity, 11.836 English Units, or 0.5457 dyne.

The observations were made by R. A. MARR, late Assistant Coast and Geodetic Survey.

[Signed] C. A. SCHOTT,
Assistant in charge Computing Division.

COMPUTING DIVISION, COAST AND GEODETIC SURVEY,
WASHINGTON, D. C., January 26, 1891.

WHO DISCOVERED THE OPTICAL PROPERTIES OF LENSES?

PACIFIC CHEMICAL WORKS, 718 MONTGOMERY ST.,
SAN FRANCISCO, October 27, 1890.

PROF. E. S. HOLDEN, Mt. Hamilton.

DEAR SIR: I am in receipt of your letter dated October 15th, and at your request have copied the whole of Chapter XXVI, containing the reference to HOSTIUS, the ancient optician.* Thinking that Chapter LI might interest you, I have had that copied also.

* Which Professor HANKS was the first to find and to which he had called my attention.

AGRIPPA alludes to astronomical subjects in several chapters, as follows:

Astronomy,	Chapter 30,	folio 82,	7 pages.
Beginning of Natural Things,	" 50,	" 130,	2 pages.
Looking-Glasses, etc	" 26,	" 78,	(copied)
Judicial Astrology,	" 31,	" 88,	11 pages.
Optics and Perspective,	" 23,	" 67,	2 pages.
Plurality of Worlds,	" 50,	" 131,	(copied)

I cannot find any other account of HOSTIUS; but in "ADAMS' Classical Biography," London, 1802, I find, under the head of "COELIUS," "An Ancient Roman Historian," three references to LIVY: Book 21, Chap. 28; Book 22, Chap. 31; Book 23, Chap. 62. In LIVY I find these references to COELIUS, as an author of importance. The first writings of LIVY are said to date back to 29 to 25 B. C. COELIUS ANTIPATER wrote 125 B. C. (Universal Pronouncing Dictionary of Biography and Mythology, vol. 1, fol. 633.) CŒLIUS AURELIANUS, a physician, lived between 100 and 300 A. D. He cannot be the COELIUS quoted by LIVY. RUFUS CŒLIUS, 82–48 B. C., was an orator, but was not accredited with being an author. Very truly yours,

HENRY G. HANKS.

"Of Prospective, and Looking-Glasses. Chap. XXVI, fol. 73.

"To return to Opticks, to which the use of Looking-Glasses and Prospective-Glasses does mainly conduce; the Experiments whereof are daily seen in the various kinds of Glasses, Hollow, Convex, Plane, Pillar-fashion'd, Pyramidal, Globular, Gibbose, Orbicular, full of Angles, Inverted, Everted, Regular, Irregular, Solid and Perspicuous. *So we read, as Celius in his ancient writings relates, That one Hostius, a Person of an Obscene Life, made a sort of Glasses that made the object seem far greater than it was; so that one Finger should seem to exceed the whole arm, both in bigness and thickness.* There is also a sort of a Glass, wherein a man may see the Image of another man, but not his own; and another, which being set in such a posture and place, gives back no representation; but the posture being altered, presently returns the Object presented. Some that shew all sorts of representations; some not all, but many. Other Glasses there are, that contrary to the fashion of all others, will shew the right hand directly opposite to the right, and the Left directly opposite to the Left. Other Glasses there are that do not represent the Image within, but as it were hanging in the Air. Burning-Glasses there are too, that Collecting the beams of the Sun into one point, kindle fire at a distance upon any combustible matter. Little Perspicuous Glasses also are not without their Impostures, that is to say, to make a little thing appear great; those that are afar off, near; those things or places that are near, afar off; those that are above us, below us; those things that are below us, above us; or in any other posture or situation whatever. There are other of these Glasses that make one Object appear to be many, and will represent things with diverse colours like the Rainbow; as also, in diverse Shapes and Figures. And I myself have learnt to make Glasses, wherein, while the Sun shines, you may discerne for the distance of Three or Four Miles together, whatever places are enlightened or overspread by his Beams. And this is to be admired in plain Glasses, that by how much less they are, so much less than themselves they will represent the object; but let them be never so big, yet shall they not represent the Object even a whit the larger; which when ST. AUSTIN consider'd writing to NIBRIDIUS he conceives it to be something of an occult mystery. However, they are vain and useless things, invented only for Ostentation and Idle Pleasure. Many both Greek and Latine have treated on Looking-Glasses and Perspectives, but above all the rest, VITELLIUS."

(From) The Vanity of Arts and Sciences, by HENRY CORNELIUS AGRIPPA, Knight, Doctor of Both Laws, Judge of the Prerogative Court, and Counsellour to Charles the Fifth, Emperour of Germany.

ECCLES.

Vanity of Vanities, All is Vanity.

LONDON, 1676.

This very interesting extract has a real importance. It is necessary to fix certain dates and to identify certain persons. AGRIPPA (1486–1535 A. D.) is, of course, well known. But who is COELIUS? Again, and most important, who is HOSTIUS, and at what date did he live and write? The feeble resources of the Library of the Lick Observatory gave no light on these questions, which Professor HANKS had not been able to settle, and accordingly I transmitted the papers to Professor STRINGHAM, who has been kind enough to make a thorough search in the excellent Library of the University of California, at Berkeley. Professor STRINGHAM has prepared a brief memorandum on the subject, which is printed below:

[*From* SMITH'S DICTIONARY OF GREEK AND ROMAN BIOGRAPHY.]

1. M. CAELIUS—Tribune in time of M. CATO, the Censor.

2. L. CAELIUS—Commanded as Legate in Illyricum in the war against PERSEUS, B. C. 169.

3. P. CAELIUS—In command of Placentia in Consulate of Cn. OCTAVIUS, B. C. 87.

4. P. CAELIUS—Perhaps a son of the preceding, praetor with VERRES, B. C. 74.

5. M. CAELIUS—A Roman Knight, from whom VERRES took away, at Lilybaeum, several silver vases, in B. C. 71.

6. C. CAELIUS—Tribune of the Plebs, B. C. 51.

7. Q. CAELIUS—A friend and follower of M. ANTONIUS, attacked by CICERO.

8. CAELIUS, an usurer, with whom CICERO had some dealings.

9. (CAELIUS) ANTIPATER—Roman jurist and historian, contemporary of C. GRACCHUS (B. C. 123).

10. (CAELIUS) APICIUS—

11. (CAELIUS) BALBINUS. (CAELIUS) CURSOR (see 19). (CAELIUS) POLLIO (see 20). (CAELIUS) ROSCIUS (see 21). (CAELIUS) SABRINUS (see 22).

12. (CAELIUS) FIRMIANUS SYMPOSIUS.

13. (CAELIUS) VINICIANUS. (CAELIUS) AURELIANUS (see 24).

14. "COELIUS, römischer Volkstribune, setzte (635)* die nach ihm benannte *lex Coelia babellaria perduellionis* durch. . . . "
[ERSCH und GRUBER.]

15. COELIUS (C) CALDUS, römischer Consul mit L. DOMITIUS AHENOBARBUS (658). [ERSCH und GRUBER.]

16. "COELIUS (M.) RUFUS.— . . . Ausgezeignet als Redner, und vielleicht der Gelungeneste unter CICERO's Schülern, der ihm als Jüngling auf seines Vaters Bitte zuerst in das Forum einführte. . . . " [ERSCH und GRUBER.]

16. "COELIUS RUFUS, b. 28 May, 82 B. C.; d. 48 B. C. Orator and Politician. Tribune in 52, Prætor in 49.
[Nouv. Biogr. Gen.]

* A. U. C.

17. "COELIUS wird unter den Anführern genannt, welche die Flotte des ANTONIUS in der Schlacht bie Actium befehligten. . . "

[ERSCH u. GRUBER.]

18. "COELIUS (C.) (nach andern war sein Name C. CAECILIUS RUFUS), war (770; N. Chr. G. 17) mit L. POMPONIUS FLACCUS im Consulat. . . ." (Tacit. Ann. II, 41.)

[ERSCH u. GRUBER.]

19. "COELIUS CURSOR, ein römischer Ritter. . . ." in reign of TIBERIUS (Tacit. Ann. III, 37, 38.)

[ERSCH u. GRUBER.]

20. COELIUS POLLIO—Roman Praefect in Armenia under NERO. (Tacit. Ann. XII, 45.) [ERSCH u. GRUBER.]

21. COELIUS ROSCIUS—Commander in Roman army (822, A. U. C.; 69 A. D.) (Tacit. Hist. I, 60, II, 65.)

[ERSCH u. GRUBER.]

22. COELIUS SABINUS (MARCUS COELIUS)—First century A. D. Jurist. Wrote *Ad Edictum Aedilium Curulium.*

[Nouv. Biogr. Gen.]

23. COELIUS RHODINGINUS (Ludovico Ricchieri). Philologian, about 1450. [Nouv. Biogr. Gen.]

24. "COELIUS, ou CAELIUS AURELIANUS, médecin latin, vivait probablement au cinquième siècle de l'ère chrétienne. On ne sait rien de sa vie, son nom même n'est pas bien connu, car on l'appelle quelquefois L. COELIUS ARRIANUS. Les manuscrits lui donnent le surnom de Siccensis, d'où on a conclu qu'il était né à Sicca Venerea, ville de Numidie. La date de sa vie ne peut être fixée qu'approximativement et par conjecture. On est certain qu'il ne vivait pas avant le deuxième siècle de l'ère chrétienne, puisqu'il a traduit SORANUS. Comme il ne fait jamais mention de GALIEN, on l'a cru antérieur à ce médecin; mais il ne cite pas non plus THÉOPHRASTE, DIOSCORIDE, CELSE, PLINE, bien qu'il ait vécu certainement après tous ces écrivains. GALIEN, de son côté, qui parle de médecins inferieurs à COELIUS n'a jamais nommé ce dernier, et on peut en induire avec quelque probabilité que celui-ci est postérieur à GALIEN. Cette conjecture, confirmée par la barbarie de style particuliére à COELIUS, a décidé REINESIUS ET HALLER a le placer au cinquième siècle après J. C. Cette date, qui fait presque de COELIUS AURELIANUS un auteur du moyen âge, son origine Africaine, et son éducation fort imparfaite sans doute, comme celle de la

plupart des médecins méthodiques, expliquent l'incorrection grossière de son style et les singuliers contre-sens qu'il commet en traduisant le grec. . . ." [Nouv. Biogr. Gen.]

"Il ne nous est resté des ouvrages de COELIUS que les suivants: *Celerum passionum libri tres* (Traité des maladies aiguës, en trois livres);—*Tardarum passionum libri quinque* (Traité sur les maladies chroniques en cinq livres). Ces ouvrages ne sont en grande partie, de l'aveu de l'auteur, que la traduction des traités aujourd'hui perdus de SORANUS. . . ." [Nouv. Biogr. Gen.]

"Le traité *Sur les maladies chroniques* fut publiée pour la première fois par J. SICHARD, BASLE, 1529, in-fol; celui *des maladies aiguës* parût d'abord à Paris, 1533, in 8°, par les soins de J. Guinter d'Andernach (Andernacus)." [*loc. cit.*]

24. "COELIUS AURELIANUS, Artzt aus Sikka in Numidien, der zu ende des zweiten und in der ersten hälfte des dritten Jahrhunderts lebte, schrieb in barbarischem Latein ein Werk über die chronischen Krankheiten in 5 Büchern, und drei Bücher über die hitzigen Krankheiten (zuerst heraug. von J. SICHARD, Basel, 1529, f.) von C. Amman mit Anmerk. u. W. B. von Almeloveen. Amst. 1709, 1722, 1755), welches ausführliche Auszüge aus verlorenen griechischen Schriften enthält. (S. C. G. KÜHN progr. in Coel. Aur. Notae. Mss. D. W. Trilleri, Leipz. 1817.)"

[ERSCH und GRUBER.]

"COELIUS AURELIANUS is probably the COELIUS that AGRIPPA refers to. The *Tardarum Passionum* of AURELIANUS was published at Basle in *1529*. AGRIPPA was in that year Historiographer to the Emperor, Charles V. The *De Incertitudine et Vanitate Scientiarum et Artium atque Excellentia Verbi Dei Declamatio* of AGRIPPA had been written in 1526, but was not published until *1530*.

25. "AGRIPPA DE NETTESHEIM (HENRI CORNÉLIUS), philosophe cabalistique, né à Cologne le 14 Septembre, 1486, mort en 1535."

[Nouv. Biogr. Gen.]

"Here is a notice concerning the only HOSTIUS to whom I have, as yet, been able to find any reference." I. S.

26. "HOSTIUS, poëte Latin, vivait dans le second siècle avant J. C. FESTUS, MACROBE, SERVIUS, citent plusieurs vers (six en tout) du premier et du second livre de *Bellum Histricum* de HOSTIUS. Ces fragments, le titre de l'ouvrage et les expressions des grammarians nous apprennent que le *Bellum Histricum* était un poëme en

vers hexamètres sur la guerre d'Illyrie, qui eut lieu sous la consulat de A. MANLIUS VULSO et de MARCUS JUNIUS BRUTUS, en 178, événement raconté dans le quarante-unième livre de l'histoire de TITE LIVE, et que le poëte vivait avant VIRGILE; mais comme aucun auteur ancien ne donne sur lui le moindre renseignement biographique, on ignore la date précise de sa vie. Des critiques ont essayé de suppléer par des conjectures au silence des anciens. Ainsi on trouve dans l'apologie d'APULÉE que le veritable nom de la CINTHIA de PROPERCE etait HOSTIA, et PROPERCE nous dit que CINTHIA avait un grand-père célèbre par son savoir:

> Est tibi forma potens sunt castae Palladis artes,
> Splendidaque a docto saepe refulget avo.

Ce grand-père de HOSTIA devait s'appeler HOSTIUS, et vivre vers le temps des Gracques. On peut sans invraisemblance le regarder comme l'auteur du *Bellum Histricum*, qui, si l'on en juge par le rudesse de la versification et du langage, doit renconter au deuxième siècle avant J. C.

[*Nouvelle Biographie Générale*, Paris, 1872.]

"The terms in which COELIUS AURELIANUS refers to HOSTIUS make it improbable that he was the HOSTIUS here described.

There is the possibility that COELIUS ANTIPATER, the historian, quoted from HOSTIUS, the poet, and that AGRIPPA quoted from ANTIPATER." I. S.

So far, Professor STRINGHAM. It has not been possible for him to find any further references of value. The extracts which he cited made it at least possible that the COELIUS in question was C. AURELIANUS, who lived in the fifth century, A. D., and whose writings were important enough to be reprinted in 1529, a year before the publication of AGRIPPA's book.

It was possible, again, that optical matters might be treated of in a work on Chronic Diseases! especially if we remember the manner in which some mediæval books were made to contain pretty much all the knowledge possessed by their authors. As a reference to the work of COELIUS AURELIANUS would settle this matter, I applied to Dr. BILLINGS, of the Surgeon General's Office in Washington, who was kind enough to have the works of C. AURELIANUS searched leaf by leaf, with the result that the name of HOSTIUS did not appear. Hence, we must abandon the hypothesis that "COELIUS" was C. AURELIANUS.

It is not at all likely that any further search in the libraries of the Pacific Coast would lead to the identification of HOSTIUS, or even of COELIUS. Some of the members of the Society in New York, Boston, Philadelphia or Washington might follow this matter further with hopes of success; and there is very little doubt that a thorough search at the British Museum would throw additional light on the interesting question.

In this connection, it may be worth while to add that thick glass *sometimes* is fractured into a natural lens. Some years ago Professor WARREN HOLDEN, of Girard College, was kind enough to send me such a lens, which had been accidentally made by a workman who was repairing the heavy glass of a skylight. It was about two inches in diameter, about half an inch thick in the centre, and approximately plano-convex, or, rather, it was more like a very flat cone. Its focal distance was about two inches, and it was capable of forming a fair image*. Once in many times such a natural lens might be accidentally formed by fracture; and one of these accidents might fall into the hands of some one who could appreciate its powers. The art of making glass has been known for at least four thousand years, and, until lately, every fragment of this material was precious, and likely to be carefully examined by intelligent workmen. There seems to be nothing strained in supposing two thousand years to be a time long enough to insure the discovery of the most obvious properties of a convex lens. E. S. H.

* This lens has been deposited in the collections of the A. S. P.

NOTE.—As everything relating to the history of the invention of the telescope is of interest I add here some references which I have lately seen. It is said that telescopes were for sale in Paris in 1609 (April) on the Pont-Marchand, and the references are to *Journal de l'Estoille*, 30 avril 1609, and to *l'Hermite du Mont-Valérien* page 1 and also to *Recueil des pièces les plus curieuses sur le connétable de Luynes*. ARAGO (*Astronomie Populaire*, vol. I, p. 178) states the same fact, but refers to *le Magasin Pittoresque* 1853, page 7. I have not been able to verify any of these references, which very likely relate to the same thing, and I give them for what they are worth. It is known that GALILEO first heard of the invention of the telescope in Venice in May, 1609, and that he immediately thereafter constructed such an instrument. If these references are added to the excellent summary which is given in the article Telescope in *Encyclopædia Britannica*, 9th edition, they render the history complete.

PHOTOGRAPHS OF THE NEBULA OF *ORION* WITH THE GREAT TELESCOPE.

On pages 57 *et seq.* of the present volume I have given a brief account of some negatives of the nebula of *Orion* made during the present opposition with the great telescope, with the special object of studying its performance on stars and nebulosity. Since that note was written Mr. SCHAEBERLE and myself have made a few exposures, and the following brief notes of a comparison of all our negatives may serve as a supplement to the conclusions previously given.

The plates employed were always Seed 26, and they have all been developed by Mr. BURNHAM. The magnitudes of the stars here given are expressed in BOND'S scale. BOND 17–18 magnitude = ARGELANDER 15 magnitude approximately.

Exposure 5^m: Star 649 (10.8 magnitude) is visible, 709 (12.3 mag.) not visible. All of the central nebulosity can be traced, but the outline of the southern apex of the Huyghenian region is very faint.

Exposure 10^m: In this negative the central portions all show well, and the brighter stars have not yet begun to destroy the effect of the nebulosity by their spreading on the plate. The faintest star visible is LASSELL'S *b*, between 685 and 708. This star was only seen twice or three times during seven years' visual observation with the 26-inch telescope at Washington. It was not seen by BOND. Its visual magnitude is probably about 15, but it shows in this negative, as well as 671 (11.5), 686 (15.6), 622 (12.7), 612 (13.5), 618 (13.1), 663 (11.7), 681 (14.8), 567 (13.9), 651 (13.1). The magnitudes in parentheses are BOND'S.

In *lacus Lassellii*, half-way between stars 641 and 651, a nebulous mass was seen at Washington, from 1878 to 1881. It was certainly not visible during the years 1874–78. This mass *(h)* is plainly visible in the negative exposed 10^m. Visual observations also show that it has materially increased in brightness since 1881.

Exposure $16\frac{1}{2}^m$: Essentially the same remarks apply to this negative as to that exposed 10^m. I might add that star 642 (15.6) has become visible, and that the detached nebulosity about star 734 just barely begins to show.

Exposure 19^m: Same remarks as for $16\frac{1}{2}^m$, except that all the details of the picture are a little clearer and more definite. The nebulosity about 734 is evident, but it extends only a few seconds from the star.

Exposure 40^m: For the examination of the brightest parts of the nebula this exposure is almost long enough. The nebulosity shows well, and the images of the brighter stars are not yet so large as to be very troublesome.

The sharp edge of nebulosity, which extends to star 793, does not show. The nebulosity about 734 does not extend more than 50″ from the star in any direction.

Exposure 60^m: On the whole, this exposure is about the best for this object with the great telescope.

Exposure 97^m: The bright central portions of the nebula have become too dense with this exposure, and the bright stars are too large, while there is little real gain in the extent of the fainter nebulosity.

Exposure 195^m: The same remarks as for 97^m. The nebulosity about 734 is now perfectly well shown.

The foregoing memoranda, which will be of little interest to those who are not familiar with the nebula, are yet of value in the comparison of the great telescope with other photographic instruments. They show that for stars and clusters it has material advantages, both in its aperture and in its long focus. For the brighter nebulæ it has advantages on account of the large scale of the picture. For the fainter nebulæ short-focused reflectors of large aperture are much to be preferred. The preceding data enable one to judge quantitatively of these points. E. S. H.

Duplicates in the Library of the Lick Observatory.

The following duplicate volumes, among others, are in the library of the Lick Observatory. All of them are neatly and substantially bound, some of them in morocco:

Arago: Astronomie Populaire, 4 vols., 8vo.

Argelander: Abo Observations, vols. 1, 2, 3, folio.

Ball: Elements of Astronomy, 1 vol., 16mo.

Berliner Jahrbuch: for 1887, 1 vol., 8vo.

Gould: Uranometria Argentina (the text only), 1 vol., 4to.

Herschel: Cape of Good Hope Observations, 1 vol., 4to.

Lamont: Catalogues of Stars, 6 vols., 8vo.

LONDON: Memoirs Royal Astronomical Society, vol. 24, 1 vol., 4to.

NEWCOMB: Popular Astronomy, German translation by ENGELMANN, 1 vol., 8vo.

TODD: Tables of the Satellites of *Jupiter*, 1 vol., 4to.

WOLF: Handbuch d. Mathematik, etc. 2 edition. 2 vols., 8vo.

We should be glad to exchange these volumes for others which are lacking and needed in our library, as for example:

ARGELANDER: OELTZEN'S ARGELANDER'S Northern Zones.

ARGELANDER: The maps (only) to the first section of the DM. (+ 90°,—2°).

ARMAGH: The first Armagh Catalogue of Stars.

BULLETIN ASTRONOMIQUE: vols. 1, 2 wanted.

HEVELIUS: Selenographia.

NATURE: Volumes 1, 2, 3, 4 wanted.

OBSERVATORY: *The Observatory*—the volumes earlier than vol. 9 are wanted.

STRUVE: Positiones Mediæ, etc. E. S. H.

GOVERNMENT AID TO ASTRONOMY IN FRANCE AND BELGIUM.

The following sums are included in the French Budget of the year 1891:

Observatory of Paris, $45,600; besides a sum of $12,000 supplementary to the appropriation of 1890.

Observatory of Meudon, $14,200.

Observatories of Algiers, Besançon, Bordeaux, Lyons, Marseilles and Toulouse, $34,340.

(Some of these observatories receive additional support from the universities, the municipalities, etc.)

Bureau of Longitudes, $29,000.

An additional sum of $36,400 is allotted to the Central Meteorological Bureau of France.

The Royal Observatory of Belgium, which is at the same time astronomical and meteorological, receives this year $12,400 for both services. —from *Ciel et Terre*, vol. 2, p. 543.

Additions to the Thirty-six Inch Equatorial.

The Driving Clock of the large telescope is actuated by a weight of 600 lbs., which requires to be wound every two hours or so. The winding used to be done by hand, and was a severe labor, requiring as it did between four and five *foot-tons* of work. A Pelton waterwheel has lately been fitted inside the iron pier (February, 1891), and connected with the winding-shaft by belting, and the clock can now be wound in less than five minutes, by opening a valve in the clock-closet, which occupies the upper section of the iron pier. Something more than 2500 *foot-tons* of actual manual labor is thus spared to us each and every year. There is no accepted unit in which to express the worry which is saved to the observer by this simple apparatus.

Two or three other simple devices have been in use for the past year, which deserve mention, as they save time. A bell is sounded by the clock-weight in its descent five minutes before a new winding is necessary. The clock itself can be stopped or started by pulling a string which hangs down along the whole length of the east side of the pier, so as to be always within reach. A square wooden frame has been fitted over the object end of the telescope to carry a common spring-roller curtain to cover the objective. The curtain will always remain fully rolled up (the objective being thus uncovered), unless a string is pulled from the eye-end. At the end of a night's work the string is made tight and fastened, and the objective is thus protected from dust without taking the time to turn the object-end down and without putting on a special cover. All these are small things, but each of them has proved to be a decided convenience. E. S. H.

A Brilliant Meteor.

A shooting star of unusual size and brilliancy was seen to pass over this city about 10:50 o'clock last evening (March 13). The light was of a bluish cast. The star appeared to pass quite close to the earth.

—(From the San Francisco *Chronicle*, March 14, 1891.)

Minutes of the Meeting of the Directors A. S. P., held in the Rooms of the Society, March 28, 1891, from 7:30 to 8 p. m.

A quorum was present. The minutes of the last meeting were approved.

Mr. H. F. Newall, Observatory, Cambridge, England, Mr. J. C. Cebrian and Dr. J. Callandreau of San Francisco were duly elected life members.

The following active members were duly elected:

Members elected March 28, 1891.

Prof. Ira W. Allen,	2251 Calumet Ave., Chicago, Ill.
F. S. Archenhold,	Gesellschaft Urania, Berlin, Germany.
Charles T. Blake,	Berkeley, Cal.
Anson Stiles Blake,	Berkeley, Cal.
California Camera Club,	819 Market Street, S. F., Cal.
Francis G. du Pont,	Wilmington, Delaware.
S. Wilson Fisher,	1502 Pine Street, Philadelphia, Pa.
Mrs. Sarah B. Gamble,	1222 Pine Street, S. F., Cal.
Miss Estella L. Guppy,	San José, Cal.
Wm. Sturtevant Harlow,	Oakland, Cal.
Prof. Mellen W. Haskell,	University of California, Berkeley.
L. J. Holton,	1207 Seventeenth St., Alameda, Cal.
T. C. Johnston,	27 Market Street, S. F., Cal.
C. B. Kendall,	137 Montgomery St., S. F., Cal.
Camilo Martin,	411½ California Street, S. F., Cal.
Lewis A. Pagin,	122 S. Market Street, Chicago, Ill.
Oliver E. Pagin,	Room 40, U. S. Custom House, Chicago, Ill.
Miss Elizabeth H. Pearson,	219 Savin Hill Avenue, Boston, Mass.
Archer B. Pierce,	University of California, Berkeley.
The Earl of Rosse,	Birr Castle, Parsonstown, Ireland.
A. L. Smith,	23 Washington Street, Chicago, Ill.
Harry W. Syz,	410 California Street, S. F. Cal.
Joseph B. Walker,	Geological Survey, Austin, Texas.

The Resignation of F. G. Blinn was received and accepted.

The following action of the Directors in conjunction with Hon. Joseph A. Donohoe was ordered to be printed:

Amended Regulations for the Bestowal of the Comet Medal.

San Francisco, February 26, 1891.

The Committee on the Comet-medal having recommended certain changes in the rules relating to its bestowal, and the founder of the medal having signified in writing his consent to these changes, we the undersigned members of the Board of Directors A. S. P. hereby vote for the acceptance of the rules as changed and as written below.

William Alvord; Chas. Burckhalter; C. M. Grant; C. B. Hill; Edward S. Holden; E. J. Molera; W. M. Pierson; J. M. Schaeberle; F. Soulé.

COMET MEDAL OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC.

I. A medal of bronze is established as a perpetual foundation to be given for the discovery of comets, as follows:

The medal is to bear on the obverse side the effigy of a bright comet among stars, with the legend "ASTRONOMICAL SOCIETY OF THE PACIFIC" around the border; and on the reverse the inscription, "THIS MEDAL FOUNDED IN 1890 BY JOSEPH A. DONOHOE, IS PRESENTED TO..........(the name of the discoverer) TO COMMEMORATE THE DISCOVERY OF A COMET ON........(the date)."

It is to be understood that this medal is intended solely as a recognition of merit, and not as a reward.

II. The medal will be given to the actual discoverer of any unexpected comet.

III. The discoverer is to make his discovery known in the usual way, and, in order to simplify the work of the committee, which, in certain cases may be called upon to consider the merits of several independent discoveries of the same object, he should also address a letter to the Director of the Lick Observatory, which should state the exact time of the discovery, the position of the comet, the direction of its motion (when this can be determined), and the physical appearance of the object.

No application for the bestowal of the medal is required. The letters received from discoverers of comets will be preserved in the records of the Lick Observatory. Cable telegrams to the Lick Observatory are to be addressed to "Astronomer, San Francisco."

IV. All communications will be referred to a committee consisting of the Director of the Lick Observatory, ex-officio, and of two other persons, members of the Astronomical Society of the Pacific, who are to be annually appointed by the Board of Directors. The decisions of this committee are to be final upon all points relating to the award of the medal. The committee will print an annual statement of its operations in the publications of the Society.

Under ordinary circumstances the comet medal will be awarded within two months after the date of the discovery. In cases of doubt a longer period may elapse. The medal will not be awarded (unless under the most exceptional circumstances) for the discovery of a comet until enough observations are secured (by the discoverer or by others) to permit the calculation and verification of its orbit.

V. This medal is to be a perpetual foundation from and after January 1, 1890.

It was reported by Mr. HOLDEN that he had turned over to Mr. BURCKHALTER on March 24, the bond of the Treasurer, the receipt (No. 2796) of the French Mint for the dies of the Comet-medal, and bank-books Nos. 50,715, 51,529 (S. F. S. U.) and 64,347 (G. S. & L. S.) as well as all the remaining blank diplomas and the original drawing of the diploma.

The Notices to Members as printed on the last page of the present number of the Publications were authorized. Adjourned.

MINUTES OF THE MEETING OF THE DIRECTORS A. S. P., HELD IN THE ROOMS OF THE SOCIETY, MARCH 28, 1891, FROM 9:30 TO 10:30 P. M.

The new board of Directors was called to order by Mr. HOLDEN. A quorum was present. The minutes of the last meeting were approved. The business in hand being the election of officers for the ensuing year, Mr. PIERSON was duly elected President of the Society and took the chair.

The following officers were duly elected:

Vice Presidents: Messrs. SOULÉ, SCHAEBERLE and MOLERA.

Secretaries: Messrs. BURCKHALTER and KEELER.

Treasurer: Mr. ZIEL.

The President was authorized to appoint the various Standing Committees and accordingly made the following selections:

Finance Committee: F. R. ZIEL, S. G. HILBORN and CHAS. BURCKHALTER.

Library Committee: E. J. MOLERA, OTTO VON GELDERN and CHASE GITCHELL.

The other Standing Committees are:

Committee on Publication: Messrs. HOLDEN, KEELER, YALE.

Committee on the Comet Medal: Messrs. HOLDEN (*ex-officio*), SCHAEBERLE, BURCKHALTER.

The following resolutions were adopted:

Resolved, That the Directors of the Astronomical Society of the Pacific sincerely regret that Prof. HOLDEN feels called upon to decline a further election as President of the Society, on account of his other pressing duties.

Resolved, That they extend to him their thanks for his valuable services as President in building up and fostering the interests of the Society, and placing it on a basis where its success is assured.

It was also

Resolved, That EDWARD S. HOLDEN be and is hereby elected an Honorary Member of this Society. Mr. HOLDEN returned his grateful thanks for the honor conferred upon him but, for reasons satisfactory, begged to resign his honorary membership; and his resignation was accordingly accepted.

ANNUAL MEETING OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC, HELD IN THE LECTURE-HALL OF THE CALIFORNIA ACADEMY OF SCIENCES IN SAN FRANCISCO, MARCH 28, 1891.

The minutes of the last meeting were approved.

Mr. HOLDEN in the chair.

The Secretary read a list of seventeen presents received, and the thanks of the Society were voted to the givers.

The cordial thanks of the Society were returned to the California Academy of Sciences for their invitation to hold the meetings of March and November, 1891 and January, 1892 in the lecture-hall of the Academy building and the invitation was accepted.

The list of new members elected this day was read to the meeting.

The Committee on Nominations reported a list of names proposed for election, as follows:

For Directors: Messrs. ALVORD, BURCKHALTER, HILL, HILBORN, HOLDEN, KEELER, MOLERA, PIERSON, SCHAEBERLE, SOULÉ, ZIEL.

For Committee on Publication: Messrs. HOLDEN, KEELER, YALE.

Messrs. MCCONNELL and VEEDER were appointed as tellers. The polls were open from 8:15 to 9 P. M., and the persons above named were duly elected.

The Treasurer then read his annual report, as follows:

RECEIPTS—		
Cash balance, March 29, 1890		$1,121 75
Received from dues	$1,957 13	
Received from Publications	23 50	1,980 63
		$3,102 38
EXPENDITURES—		
For Publications and general expenses	$2,347 89	
On account of Montgomery Library Fund	9 84	$2,357 73
Cash balance in bank March 28, 1891		744 65
		$3,102 38
FUNDS—		
Alexander Montgomery Library Fund, cash balance		$1,590 11
Donohoe Comet Medal Fund, cash balance		527 35
Cash in bank (General Fund)		744 65
Total Cash on hand		$2,862 11

The Committee appointed to audit the Treasurer's accounts reported as follows, and the report was accepted and adopted and the Committee discharged.

To the Board of Directors of the

ASTRONOMICAL SOCIETY OF THE PACIFIC: GENTLEMEN—

Your Committee, appointed to audit the accounts of the Treasurer, have made an examination of said accounts for the year ending March 28th, 1891, and report as follows:

RECEIPTS—		
Cash balance, March 29th, 1890		$1,121 75
Received from dues	$1,957 13	
Received from sale of Publications	23 50	1,980 63
		$3,102 38
EXPENDITURES—		
For Publications and general expenses	$2,347 89	
Account Montgomery Library Fund	9 84	$2,357 73
Cash balance in bank March 28th, 1891		744 65
		$3,102 38
FUNDS—		
Alexander Montgomery Library Fund, cash balance		$1,590 11
Donohoe Comet Medal Fund, cash balance		527 35
Cash in bank		744 65
Total Cash on hand		$2,862 11

F. R. ZIEL,
A. O. LEUSCHNER,
J. H. JOHNSON.

SAN FRANCISCO, March 28th, 1891.

REPORT OF THE COMMITTEE ON THE LIBRARY, SUBMITTED MARCH 28, 1891.

To the Board of Directors of the

ASTRONOMICAL SOCIETY OF THE PACIFIC: GENTLEMEN—

We, the undersigned, Committee on the Society's Library, respectfully report as follows:—

The library consists, at present, of 491 volumes, 431 of which belong to the Alexander Montgomery Library, and were purchased by us with the Alexander Montgomery Fund, and 60 volumes derived from other sources, by contribution and purchase.

The cost of the Alexander Montgomery Library to date, has been $1,017.24, thus exhausting that portion of the fund, viz: $1,000, which was directed to be invested in the library. There remains on hand the interest on $1,500, which amounts to about $75 per annum, which interest we are permitted to employ in adding to the library.

Your Committee, in making investments in books for the Alexander Montgomery Library, have had in view the purchase of such books as would stimulate the study of Astronomy, rather than the more technical books which would be of service to the professional and veteran astronomer. The latter books, however, are indispensable, and we would recommend that hereafter the revenue derived from the remainder of the Alexander Montgomery Fund should be applied to the purchase of the more technical and recondite works on Astronomy.

Respectfully submitted,

E. J. MOLERA,
WM. M. PIERSON,
CHAS. BURCKHALTER,
Committee.

The above report was accepted and adopted.

REPORT OF THE COMMITTEE ON THE COMET MEDAL, SUBMITTED MARCH 28, 1891.

The Comets of 1890 have been:

Comet *a*, discovered by W. R. BROOKS, at Geneva, New York, March 19.

Comet *b*, discovered by J. COGGIA, at Marseilles, July 18.

Comet *c*, discovered by W. F. DENNING, at Bristol, July 23.

Comet *d*, (D'ARREST's periodic comet) re-discovered by E. E. BARNARD, at Mt. Hamilton, October 6.

Comet *e*, discovered by T. ZONA, at Palermo, November 15.

Comet *f*, discovered by R. SPITALER, at Vienna, November 16.

Medals have already been delivered to Messrs. BROOKS, COGGIA, DENNING, SPITALER, and ZONA.

In November last, Mr. BARNARD addressed a letter to the Committee giving reasons why the medal should not be awarded for the discovery of periodic comets, especially as recent observations have made it at least possible that the brighter periodic comets may be followed throughout their whole orbits, and he signified his desire that the medal should not be awarded to him for the rediscovery of D'ARREST's comet, although the Committee was prepared to make the award. In some other respects also the rules were found to be cumbrous. They have accordingly been *thoroughly revised* and submitted to the founder, who has signified his acceptance of the changes, and in their revised form they were adopted by the Board of Directors on February 26, 1891, as printed in this number of the Publications. The amended rules take effect therefore on February 26, 1891. Copies of the new rules have already been sent to the principal astronomical journals and to all our corresponding observatories and institutions.

Respectfully submitted,

EDWARD S. HOLDEN,
J. M. SCHAEBERLE,
CHAS. BURCKHALTER.

The following resolution was adopted:

Resolved, That all the acts appearing in the minutes of the Board of Directors of this Society as having been done by said Board since the incorporation of the Society are here now by this Society approved and confirmed.

Article IX of the By-Laws of the Astronomical Society of the Pacific as refers to the regular meetings of the Society was amended by the consenting votes of Messrs. ALVORD, BURCKHALTER, GRANT, HILL, HOLDEN, MOLERA, PIERSON, SOULÉ, ZIEL, to read as follows:

Meetings shall be held in the Library of the Lick Observatory, Mt. Hamilton, at a suitable hour on the second Saturday in June and the first Saturday in September, and meetings shall be held in the rooms of the Society in San Francisco at 8 o'clock P. M. on the last Saturdays of January, March and November.

It was, on motion,

Resolved, That the President be authorized to appoint a committee of seven members to make arrangements for an astronomical exhibit at the Columbian Exposition in Chicago. The following committee was named:

Professor G. W. HOUGH, Mr. G. E. HALE, Mr. G. A. DOUGLASS, Mr. R. W. PIKE,	of the Chicago Section.
Mr. W. M. PIERSON, Mr. C. B. HILL,	of San Francisco.
Mr. A. J. BURNHAM,	of Mt. Hamilton.

The following papers were announced:

a. "The Fireball in RAPHAEL'S Madonna di Foligno," by Professor H. A. NEWTON, of Yale University.

b. "On the Similarity of Certain Orbits in the Zone of Asteroids," by Professor D. KIRKWOOD, of Riverside.

c. "Astronomical Observations during 1890," by TORVALD KÖHL, of Odder, Denmark.

d. "Address of the Retiring President of the Society," by Professor HOLDEN, Mt. Hamilton.

e. "A Few Hints to Beginners in Solar Observations," by Miss E. BROWN, of England.

f. "Lunar Work for Amateurs," by THOS. GWYN ELGER, F. R. A. S., of England.

g. "The Total Solar Eclipse of January, 1889," by Prof. H. S. PRITCHETT, Washington University, St. Louis.

LORD ROSSE was introduced to the meeting by the President and gave an account of the working of his great reflectors with especial reference to certain physical researches—as in celestial spectroscopy and photography and in heat-measurements. The performance of reflectors and of refractors in such work was compared and the conclusion was drawn that a large field of labor remains open to the reflector in spite of the admirable performance of great refractors, like that at Mount Hamilton.

The thanks of the Society were returned to LORD ROSSE.

Attention was called to an interesting letter to be printed in the *Publications*, entitled "Who Discovered the Optical Properties of Lenses?" by Professor H. G. HANKS.

The President then read his annual address. Adjourned.

MINUTES OF THE THIRD AND FOURTH MEETINGS OF THE CHICAGO SECTION A. S. P., FEBRUARY 2 AND MARCH 2, 1891.

The third regular meeting of the Chicago Section of the A. S. P. was held Monday evening, February 2, 1891 at the Sherman House, Chicago. The chairman presided. The minutes of the last meeting were accepted as read. The Secretary announced the receipt of a letter from Professor HOLDEN stating that an amendment to the Constitution of the A. S. P. authorizing the formation of Sections had been passed by the Board of Directors. A few unimportant matters of business were reserved for future consideration.

A lecture on "The Astronomical Discoveries of the Spectroscope" was then given by GEORGE E. HALE. A general explanation of the principles of spectrum analysis was followed by an account of the methods used in comparing solar and metallic spectra. The prominences were then spoken of, and the spectroscopic method of observing them described, together with the measurement of motion in the line of sight by means of the distortion of lines in prominences and spots. Photography was next referred to, especially in connection with the work on stellar spectra carried on at the Harvard Observatory. The meteoritic hypothesis was outlined, and the discovery of the duplicity of β *Aurigae* and the dark satellite of *Algol* explained. Illustrations were given by means of a lantern, the slides including a set from the Harvard College Observatory and several photographs of solar and arc spectra.

After a hearty vote of thanks to Mr. PEARCE for the use of the parlors of the Sherman House the meeting adjourned.

The following have been added to the list of members since the last meeting:

Mrs. MARY H. WILLMARTH,* 222 Michigan Boulevard, Chicago.

Mr. H. A. ALLEN, 396 Kenilworth Place, Milwaukee, Wis.

Professor C. A. BACON, Beloit College, Beloit, Wis.

Mr. OLIVER E. PAGIN, Room 40, Custom House, Chicago.

Mr. LEWIS A. PAGIN, 122 S. Market Street, Chicago.

Mr. A. L. SMITH, 23 Washington Street, Chicago.

GEORGE E. HALE, Secretary.

The fourth regular meeting of the Chicago Section of the A. S. P. was held Monday evening, March 2, 1891, at the Sherman House, Chicago.

Mr. DOUGLASS was in the chair.

The minutes of the last meeting were accepted as read.

The Secretary opened a discussion as to an astronomical exhibit at the World's Columbian Exposition, and held that apparatus as well as photographs could be secured.

Prof. HOUGH followed with a few remarks as to the desirability of such an exhibit.

Mr. PIKE desired that a committee be appointed to attend to the matter.

The Secretary stated that a committee was to be appointed by the A. S. P. with several members from the Chicago Section.

Dr. EWELL believed that the exhibit should contain both astronomical photographs and apparatus. He cited the case of the Chicago Microscopical Society, whose committee was already in correspondence with the leading microscope makers in this country and abroad. In regard to our own committee he moved that three or four names be suggested by our Executive Committee to serve on the regular committee of the A. S. P.

This was seconded by Prof. HOUGH, and carried.

The Secretary then brought up the subject of variable stars, and exhibited in this connection a number of star-trails photographed with a stationary camera and a Darlot or Laverne lens.

A general discussion followed, touching on the questions of exposure, plates, foci of lenses, etc.

Mr. ELLERMAN exhibited trial plates of *Orion*, the *Pleiades*, *Ursa Major*, and the polar region.

Mr. PIKE then read an interesting paper illustrated by blackboard figures on the ancient symbols and beliefs respecting the Triangle.

The meeting then adjourned.

The following have been suggested for membership on the Committee on the World's Columbian Exposition of the A. S. P.

Messrs. DOUGLASS, HOUGH, PIKE, HALE.

Prof. IRA W. ALLEN, 2251 Calumet Avenue, Chicago, has been added to the list of members of the Chicago Section, A. S. P.

GEORGE E. HALE, Secretary.

OFFICERS OF THE SOCIETY.

WM. M. PIERSON (508 California Street, S. F.),	*President*
FRANK SOULÉ (Students' Observatory, Berkeley),	*Vice-Presidents*
E. J. MOLERA (850 Van Ness Avenue, S. F.),	
J. M. SCHAEBERLE (Lick Observatory),	
CHAS. BURCKHALTER (Chabot Observatory, Oakland),	*Secretaries*
JAMES E. KEELER (Lick Observatory),	
F. R. ZIEL (410 California Street, S. F.),	*Treasurer*

Board of Directors — Messrs. ALVORD, BURCKHALTER, HILBORN, HILL, HOLDEN, KEELER, MOLERA, PIERSON, SCHAEBERLE, SOULÉ, ZIEL.

Finance Committee—Messrs. ZIEL, HILBORN, BURCKHALTER.

Committee on Publication—Messrs. HOLDEN, KEELER, YALE.

Library Committee—Messrs. MOLERA, VON GELDERN and GITCHELL.

Committee on the Comet Medal—Messrs. HOLDEN *(ex-officio)*, SCHAEBERLE, BURCKHALTER.

OFFICERS OF THE CHICAGO SECTION.

Executive Committee—Messrs. DOUGLASS (Chairman), EWELL, HALE (Secretary), PIKE, THWING.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the Publications for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of one dollar to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to The Librarian of the Mercantile Library, 226 Bush Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend any or all of the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific," at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

THE CORONA.

FROM PHOTOGRAPHS BY WASHINGTON UNIVERSITY ECLIPSE PARTY.

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

VOL. III. SAN FRANCISCO, CALIFORNIA, JUNE 13, 1891. NO. 16.

THE SOLAR CORONA OF JANUARY, 1889, FROM THE PHOTOGRAPHS.

By Professor H. S. Pritchett.*

The photographic testimony as to the form of the Sun's corona, obtained on the occasion of the eclipse of January 1, 1889, exceeds in amount and completeness of detail the results obtained on any similar occasion, with the single exception that the observing parties were confined to a small part of the path of totality.

Of the photographic parties, but three, so far as my information goes, were provided with equatorial cameras, equipped with driving-clock, making long exposures possible. These were the Lick Observatory party at Bartlett Springs, the Harvard College party at Willows, and the Washington University party at Norman, all three places being in the State of California.

Up to the present the only publication of photographic results from these observing parties has been that of the Lick Observatory. The report of the work of the Washington University party is now going through the press. As a large number of the members of the Astronomical Society of the Pacific were engaged in observations of that eclipse, a brief statement of the results obtained at Norman, so far as the form of the corona is concerned, may be of interest.

STATION AND EQUIPMENT.

The Washington University party was stationed at Norman, a small hamlet on the Southern Pacific Railway. The geographical co-ordinates of the station are:

Latitude, - - $39^\circ\ 24'\ 58''.8$

Longitude, - $8^h\ 08^m\ 45^s.39$

* Washington University, St. Louis, Missouri.

The photographic equipment consisted of an equatorial camera, having for its objective one of DALLMEYER'S patent portrait and group lenses of the size known as No. 8 D. The instrument is the property of the U. S. Naval Observatory, and was used in the eclipse of 1878 at La Junta, Col. It has a clear aperture of 6.0 inches, and an equivalent focal length of 37.9 inches. The tube was mounted upon a equatorial stand belonging to one of the five-inch equatorials used in the transit of Venus observations. This stand is very firm; has divided circles on both axes, and was provided with an excellent clockwork. The visual and photographic foci of this lens coincide; the instrument was, therefore, adjusted by the eye, and this adjustment tested by numerous photographic experiments before the day of eclipse. The plates used were SEED'S 26. With these it was found almost impossible to make the tube light-tight without using an automatic shutter. The largest shutter which could be procured in St. Louis was one worked by the ordinary air-bulb, having a clear aperture of 4.5 inches. This cut down the effective aperture of the lens from 6 to 4.5 inches, but probably increased the sharpness of the negatives.

The orientation of the plates was provided for by reading with a clinometer the inclination of the edge of the plate-holder to the horizon.

THE NEGATIVES.

It is manifestly impossible to obtain on a single negative a good representation of both the outer and inner corona. A negative properly exposed for the bright inner corona would be under-exposed for the outer, and *vice versa*. It was decided, therefore, to make exposures of various lengths, from nearly instantaneous up to about thirty seconds. Seven plates were exposed, but the last one was lost by the sticking of the slide in the plate-holder. The length of exposure for each negative is given in the description of the negatives which follows. The photographic equatorial was in the hands of Professors NIPHER and CHARROPPIN. The negatives were developed at Norman by Professor CHARROPPIN. Those of short exposure were lacking in density for printing purposes, but this was rather an advantage than otherwise, as it brought out admirably the details of the filaments and streamers.

Negative No. 1.—This negative, taken immediately after the beginning of totality, had an exposure of less than half a second. The polar filaments form the prominent feature of the negative. The corona is shown to a distance of three-fourths of a diameter from the sun's disc.

Negative No. 2.—The time of exposure was 3.0 seconds. The polar filaments are a marked feature of this negative, also, the corona being shown to a distance of a diameter and a quarter from the disc.

Negative No. 3.—This negative, which was the first one developed, had an exposure of a little more than six seconds. The equatorial streamers can be seen to a distance of one and a half diameters from the disc. Two large prominences are shown on the western line and five on the eastern line.

Negative No. 5.—This negative had a longer exposure than any of the rest—about twenty-eight seconds. The corona is shown to a distance of more than two diameters from the disc.

Negatives No. 4 and No. 6 of eighteen seconds and thirteen seconds exposure, respectively, differ but little from No. 5.

All the negatives of long exposure show a curious diffraction ring in the center of the black disc of the Moon.

REPRODUCTION FROM THE NEGATIVES.

As just stated, several of these negatives, while very sharp and showing great detail in the structure of the corona, are lacking in density for printing. Furthermore, it is impossible for any one negative to give a fair representation of the entire corona. In the publication of the observations of the Washington University, four of the negatives described above are reproduced by the artotype process. The negatives chosen for reproduction were those numbered 1, 2, 3 and 5, and include those of short exposure, of medium exposure and that of longest exposure.

It seems desirable to reproduce from the negatives a representative picture which should put into a form capable of study the entire result of the photographic work at this station; a picture, in other words, which should represent the corona as determined by all the photographs taken. The following plan was adopted, at the suggestion of Professor ENGLER:

A positive made from the negative of longest exposure was placed in an ordinary stereopticon, and the image thus produced thrown upon a screen. The lantern was then placed in the position, determined by trial, which gave the best definition to the image on the screen, and this made the diameter of the Moon's disc about one foot. This image was then copied by hand, in crayon, with great care, by Mr. FREDERICK W. LIPPELT, a most conscientious draughtsman, whose skill in crayon work can hardly be excelled. Each negative was then in turn studied in the same way and under a magnifying glass, and every detail of the corona platted in, taking care to orient each plate properly. All of this work was subjected repeatedly to the criticism of the different members of the eclipse party, and, when completed, was artotyped by Mr. EDWARD BIERSTADT, of New York. This artotype production forms the frontispiece of the present number, and I beg to bring it to the attention of the Society as the definitive result obtained at this station for the form of the corona, a result possessing substantially the accuracy of the original negatives.

In studying this reproduction it is to be noted that the lower edge of the picture corresponds accurately to a horizontal line which is inclined at an angle of 20° 12′.3 to a parallel of declination. This method of orienting the picture was chosen to avoid the necessity of placing reference lines upon the page.

STRUCTURE OF THE CORONA.

It has been stated that the negative of twenty-eight seconds exposure showed the coronal streamers to a distance of more than a degree from the Sun. Señor VALLE, at Norman, using a disc to cover the brighter inner corona, was able to trace the streamers with the naked eye to a distance of more than three degrees. The testimony, therefore, which these negatives are able to supply, does not apply to the fainter coronal streamers outside the smaller limit mentioned above.

The marked structural features of the corona, as presented by the negatives, are [a] the so-called filaments, and [b] the streamers extending approximately in the direction of the ecliptic.

The filaments extend over a region of twenty degrees or more on each side of the poles. They are straight lines of light arranged somewhat like the spines of a fan, and are not radial. The dark spaces between them are not entirely free of coronal matter, but can be traced in some cases to within a short distance of the Sun's limb. Comparing our negatives with a copy of a negative taken by the Lick Observatory party I find the number and arrangement of these filaments to coincide accurately. There are slight differences in the lengths of some of the filaments, but no greater than might be accounted for by differences of exposure and atmospheric conditions.

The broad and strongly marked equatorial belt stretches directly across this mass of filaments, apparently cutting off the filaments at the somewhat irregular line of separation. The impression conveyed to the eye is that the equatorial stream of denser coronal matter extends across and through the filaments, simply obscuring them by its greater brightness. The effect to the eye is just as if the equatorial belt were superposed upon, or passed through, the filamentary structure. There is nothing in the photographs to prove that the filaments do not exist all round the sun.

The testimony from negatives of different lengths of exposure goes to show that the equatorial streamers are made up of numerous interlacing parts inclined at varying angles to the Sun's equator, but all trending, in a general way, along it, or, roughly speaking, along the ecliptic. The direction and character of these component streamers can be best studied at the edges of the photographs, where, on account of the smaller number shown, their direction and force can be made out. It seems probable that, could we have a faithful reproduction of the extreme outer corona, where individual streamers could be traced out for a considerable distance, our knowledge of the coronal structure would be materially increased.

VALUE OF THE PHOTOGRAPHIC TESTIMONY.

The corona, as projected on the photographic plates, may be described briefly as made up of bright streamers extending across the Sun's equator, surmounted at each pole by fainter coronal matter, traversed by non-radial rectilinear rays, or filaments. A physical and mathematical theory, which will account for this complexity of structure, becomes at once a matter of greatest interest. The resemblance of the polar filaments to the lines of force about a magnet would naturally suggest a discussion upon the basis of a magnetically polarized Sun, did it seem possible to account physically for the existence of magnetic properties under the conditions which are known to exist on the Sun.

The problem of discussing the filaments as lines of force under the assumption of an electrically polarized Sun, is also open to the objection that it is difficult to see how a difference of electrical potential can be maintained upon the solar hemispheres. Such a theory involves the assumption of some law of the electrification over the Sun's surface.

The force acting upon any point due to such electrification could then be expressed as a function of the co-ordinates of the point. Assuming such an equation of condition and comparing with the observed polar filaments considered as projected upon a plane perpendicular to the line of sight, it is possible to represent the observations equally well by numerous assumptions as to the distribution of the electrification. In fact, the polar filaments on the photographs are too short and uncertain of measurement to serve as the basis of verification of such a theory.

It does not seem easy to explain such an arrangement of matter as that shown in the photographs—assuming the coronal matter about the pole to be actually arranged in convergent lines—on the theory of gravitation alone. The assumption that the so-called polar filaments shown on the photographs are proofs of the actual arrangement of the coronal matter in lines of force, does not seem to me altogether safe. Much of this apparent arrangement may be due to perspective and irregularities in the irradiation and reflection of light.

A phenomenon strikingly suggestive of the polar filaments may be seen by looking, from a distance of a few hundred feet, at an electric light shining through an atmosphere containing large quantities of dust and smoke. The effect of alternating bright and faint streamers is produced by small dust clouds of varying density. Of course, the effect is increased in this case by the fact that the light emanates from a point.

In the absence of a theory of the filaments as lines of force which would commend itself for strong physical reasons, it seems to me that all the testimony of the negatives may be reconciled with the idea that the corona, consisting of almost infinitesimal particles, is made up of matter circulating around the Sun, or gravitating toward it, not ejected from it. Such a view would harmonize with what is known of the zodiacal light, which, it seems to me, must be included in any satisfactory explanation of the corona.

The physical condition of matter in the corona must, in all probability, be similar to that of the matter composing the tails of comets, especially in cases of near approach to the Sun. A study of the behavior of comets in their approach to the Sun will ultimately throw light on the structure of the corona. The telescopic observation of a comet very near the Sun, during a total eclipse, would form an exceptional opportunity.

It must, after all, be conceded that the value of the photographic testimony obtained during this eclipse belongs rather to the future than to the present, and that the negatives then obtained will be of increasing value as they come to be compared with negatives obtained during future eclipses.

SUGGESTIONS FOR THE FUTURE.

It would seem to be a matter of importance that original negatives, obtained during various eclipses should, as years go by, be placed in secure hands where they may be accessible to all astromomers. The National Observatory, which is soon to have a new building, provided with proper vaults, would seem to be the proper repository for such photographic records.

As a result of the study of the photographs of the January eclipse of 1889, the two following points seem to me to demand at present special attention from eclipse observers:

1.—The desirability of obtaining photographs of the outer coronal streamers, whose delineation would doubtless go far toward a real knowledge of the structure of the corona. This involves the problem of designing the photographic outfit specially for this work.

2.—The desirability of photographing the corona from points as widely separated as possible.

In 1871 the corona was photographed from points in India and Java, separated by 2000 miles. The next total eclipse available for observation, occurring April 15–16, 1893, will present a most excellent opportunity for such observations. This eclipse begins in the South Pacific Ocean; is total on the west coast of South America at 0^h Gr. M. T.; is total on the east coast of South America at 1^h Gr. M. T., and crossing the Atlantic the shadow cone reaches the west coast of Africa at 2^h Gr. M. T. The shadow cone first touches the South American continent at Sarco, in Chile, latitude 29° south, and, crossing Chile, traverses the Argentine Republic, passing nearly 400 miles north of Cordoba, and touching the corner of Bolivia, passes directly through Brazil and reaches the Atlantic at Forteleza, in the Province of Ceara, in latitude 4° south. Then, crossing the Atlantic, the shadow cone will arrive one hour later at the west coast of Africa, entering it near Albreda, in Senegambia. It finally leaves the earth at a point some 2500 miles in the interior, situated in the Great Sahara Desert.

At least one good observing station can be reached in Chile; a number are available in Brazil, and at least one in Africa. Between observations in Chile and those in Africa there would be an interval of over two hours. When it is remembered that the duration of totality will be over 4½ minutes, it will be seen how favorable are the circumstances of this eclipse. Photographs of the corona taken by parties in Chile, Ceara and Senegambia would go far toward solving some of those problems of the corona which seem ripe for solution at the present time. To make the results strictly comparable the photographic equipments should be similar, and the negatives developed by the same operator, using the same method of development.

In the matter of eclipse observation, as in other departments of astronomical work, an intelligent co-operation among astronomers of different nationalities would go far toward increasing the value of the results. The elaboration of some feasible plan for securing co-operation in the observations of this important eclipse might, it seems to me, be very properly undertaken by this Society, which had its practical beginning in the co-operation of observers of the eclipse of January, 1889.

WASHINGTON UNIVERSITY, January, 1891.

LUNAR WORK FOR AMATEURS.

By THOMAS GWYN ELGER, F. R. A. S.

As it may undoubtedly be assumed that a majority of those who join a Society like this are desirous of undertaking active work of some description, and that all who possess suitable telescopes are anxious so to employ them as to add something, however little, to the general sum of astronomical knowledge whatever branch of observation they wish to pursue,—the following short paper on Lunar Observation may, perhaps, be acceptable to those who are thinking of turning their attention to this promising and attractive subject.

To the observer possessed of a moderate-sized telescope,—*i. e.*, an achromatic of from 4-in. to 8-in. aperture, or a reflector of from 6-in. to 12-in., the study of the Moon's surface opens up a practically inexhaustible field for work, which, if he sets about it on a definite plan, cannot fail to be of more or less permanent value. It must be remembered that we really know very little about lunar details. Excellent charts have been published, showing all the principal "seas," walled and ringed plains, craters of various sizes, mountain ranges, together with ridges, rills and innumerable other features, but a very short experience with a good instrument, within the limits of size just mentioned, will suffice to show that the best of these maps is very far from being exhaustive, and that, if we take the trouble to make a special study of any particular formation, we shall find, long before much progress has been effected, that a number of hitherto unrecorded objects has been noted. No matter to which formation the observer directs his attention, this will be his experience, and he will discover, moreover, as he continues his scrutiny from lunation to lunation, that more and more objects will be revealed, as his eye becomes more and more familiar with the region he is studying. This education of the eye is not the least useful benefit he will acquire by devoting himself to a definite line of observation, as it will ultimately give him an immense advantage over desultory gazers, even though they be furnished with much larger instruments. It has been truly said, that the value of a telescope above a certain size, as a means of research, depends less upon its actual aperture than upon the man at the eye-piece, and in no branch of observational astronomy is the truth of this statement more strikingly exemplified than in selenography. As an illustration of the effect of the continued study of delicate lunar details, I may, perhaps, be pardoned for a brief reference to my personal experience. Some five and twenty years ago, becoming possessed of an excellent 4-in. achromatic, by COOKE, of York, I commenced to scrutinize the floor of the fine walled-plain *Plato*, and was disappointed and chagrined to find that, with all attention and under the best atmospheric conditions, only three or four of the light spots and one or two faint streaks were visible in the interior, while other observers, with very similar optical means, had detected very many more of these objects, and regarded those which I noted, as easy. A few weeks sufficed to show me, however, that the fault lay not with Mr. COOKE's handiwork, but with myself; or, in other words, was due to want of experience and familiarity with the minute features of the formation; for, as time went on, additional light spots and streaks were revealed, so that, ultimately, I saw as many as my fellow-observers. The training received by the eye, even in so short a time, was, in fact, tantamount to a notable increase in the light-giving and optical capacity of the telescope. My experience will, I think, be confirmed by that of many other observers.

The beginner, then, is strongly recommended to devote his attention to some particular lunar formation, and to make an exhaustive study of it under as many different phases of illumination as possible, selecting at first one of moderate extent and without very complicated surroundings. He should endeavor to sketch it from night to night, so that he may have a more or less accurate record of its appearance under various conditions. *Timocharis* and *Lambert*, in the *Mare Imbrium; Reinhold* and *Landsberg*, south of *Copernicus; Marius*, in the *Oceanus Procellarum; Taruntius* in the *Mare Fœcunditatis;* are all objects of a comparatively simple type, which will well repay careful observation. Commencing his work when the selected formation is in close contiguity to the morning "terminator," or ever-shifting division line between the illuminated and unilluminated portion of the Moon, that is, when the Sun is rising above the horizon of the object, he should watch the effects of the gradual illumination of its details, noting the lighting-up of the peaks or loftier portions of the ring and the projections of their shadows. As sunrise advances, the form and position of these shadows should be carefully sketched, the time of observation being accurately recorded, and the ridges, hills, clefts and other details duly noted and drawn. On the following night, if the weather permits, the work should be repeated, and so on, from night to night, as often as occasion offers, till he has a more or less complete series of pictures of the formation, extending from sunrise to sunset, when, it may be confidently asserted that, if ordinary care has been taken, his drawings will be of some selenographical value, and that he will have acquired a desire to extend his labors to objects of a more complicated description. This recommendation to the beginner may, perhaps, seem somewhat too exacting, and to make demands on time and patience which can rarely be satisfied. If this be so in any particular case, the programme can be easily modified by reducing the number of observations to (say) one at sunrise, one between sunrise and lunar noon, one under a still more vertical sun, and one or more near sunset. These will suffice to give a tolerably accurate idea of the character of the formation and its neighborhood. The draughtsmanship of the observer has been assumed, because little progress can be made without some skill in the use of the pencil. If he does not possess this, an effort should be made to acquire it. Even in these days of celestial photography the camera has not yet succeeded in portraying innumerable lunar details revealed to the eye. Pencil and paper, moreover, are always available, and every observer should try to do his best with them, however distrustful he may be of his artistic powers. Many living selenographers who, at the commencement of their careers, were very indifferent draughtsmen, have subsequently become so skillful that all their drawings are of permanent value. Dr. WEINEK, in a recent number of this journal, has explained the method he adopts in the production of his beautiful drawings of lunar scenery. Very few observers, however, can hope to make any sensible approach to the excellent portraitures of this ardent selenographer, and must rest content with something very far short of such perfect pictorial representations. The first consideration is, of course, accuracy, and then comprehensiveness. The position of every feature shown should be fixed either by micrometrical measurement or by careful alignment, and its apparent size estimated, either in terms of a diameter of the formation with which it is associated, or of that of some other object whose relative dimensions have been so determined.

Some little experience is needed in order to appreciate the true character of lunar details,—*e. g.*, to avoid mistaking a narrow valley, or cleft, for a ridge, the shadow of a mountain mass for a deep depression, a hollow between rocks for a true crater, and so forth; and it is also very necessary to realize the actual size of the objects examined. From a want of this consideration, we are apt to overlook the significance of much that we see, and to greatly underrate the real dimensions of what appear to be insignificant details, regarding, for instance, what are really large, isolated mountains, as hillocks or mounds; radiating hills, three or four miles across, with intervening valleys of equal width, as "lava streams," and so on. In the case of a vast circumvallation like *Ptolemäus*, for example, it adds immensely to the students' comprehension of the size and character of the multitude of features it includes, both on its border and interior, to know that, speaking roughly, the area of the floor, some 115 miles in diameter, is 9000 square miles, or about equal to that of the English counties of York, Westmoreland and Lancaster combined, and that the bright crater A, which is such a conspicuous object thereon, is at least four miles in diameter and covers an area much larger than that occupied by the town of Sheffield and its suburbs. This question of scale should never be overlooked, whether the formation under examination be large or small.

Having acquired some practice in the observation of objects of moderate size and simple character, the observer should proceed to the study of another of the great walled-plains, or of some definite region presenting features of interest. Here the co-operation of several amateurs is very desirable, and not only contributes largely to the interest of the work, but to the possibility of doing far more during the course of a lunation than could be otherwise accomplished. Co-operation, of course, necessitates a director to organize the plan of observation, and to receive and discuss the results; but such an individual should be easily found among the members of a society including so many telescopists as the Astronomical Society of the Pacific. By an arrangement of this kind individual progress will be assured, and selenography will receive an impulse in the right direction. It is not desirable to lay down too rigid a system for directing the labors of such an association of lunar observers. Much should be left to be governed by individual tastes, optical means, and the capacity of the workers; the only strict stipulation being that each observer should undertake definite work of some description, and avoid merely spasmodic and desultory observations, which never lead to any useful result, but usually tend, in this and other branches of observational astronomy, to the ultimate abandonment of the telescope in favor of some other hobby or scientific toy.

One of the first requirements of the lunar observer is a good map of the Moon. BEER and MÄDLER'S large chart, 37½ in. in diameter, in four sections, with special maps on a larger scale of *Petavius*, *Hyginus*, *Triesnecker*, etc., will be found most generally useful; or, in default of this, their smaller map, 12½ in. in diameter, which is wonderfully accurate so far as it goes, but is somewhat overcrowded, owing to the smallness of the scale. NEISON'S Moon, the standard work on the subject in the English language, includes a map 24 in. in diameter, in twenty-two sections, which is also of great excellence; but the best for those who are able to pursue the subject with the aid of moderately large telescopes, is undoubtedly the magnificent chart due to the labors of the late Dr. SCHMIDT, of Athens. This is six Paris feet in diameter, and is divided into twenty-five sections. Notwithstanding the coarse style of reproduction adopted, this is the clearest and most comprehensive, showing a vast amount of detail omitted in the other maps. The student should also acquire as many good photographs of the Moon as possible, taken under different phases, as they are very useful as affording reliable representations of the coarser features of the various formations, thus furnishing him with the means of drawing their outlines, etc., at his leisure, preparatory to his own telescopic scrutiny of them, and thus saving time and trouble. They are, besides, invaluable in giving the true positions of salient points, and as a check on the accuracy of his work.

A few words may now be said to those interested in selenography who have decided, either individually or in co-operation, to follow some definite plan of procedure, as to certain lunar details which will repay systematic observation.

Walled-plains and large enclosures.—With the exception of *Plato*, *Archimedes*, *Hipparchus* and one or two others, our knowledge of the details of these formations is so slight that an experienced observer, with moderate optical means, may, on a favorable night, detect many interesting features unrecorded on the maps. Taking *Ptolemäus*, for example, as one of the most familiar of lunar objects, near the center of the disc; many gaze on this magnificent wall-plain without, perhaps, suspecting that the features shown on the floor in SCHMIDT's elaborate map amount to barely half the number that have been detected since its publication, and one may be tolerably sure that when the results of the study of this formation, now in progress under the auspices of the British Astronomical Association, are collected, very many more objects will be recorded. As regards *Plato* and *Archimedes* again, no one imagined that the floors of these formations, so sparingly covered with spots, etc., in the maps of MÄDLER and SCHMIDT, include a most remarkable system of crater-cones, craterlets, bright spots and light streaks. We may, therefore, reasonably conclude that what has been found to be the case with respect to these formations will hold true with respect to others, and that many, at present unsuspected features, will be brought to light when they are systematically surveyed and mapped. The accurate delineation and cataloguing of details of this description is of great importance in determining the vexed question of change. Unfortunately photography can, at present, render no assistance here. Some observers believe, and the writer agrees with them, that the occasional invisibility of minute features on the floors of formations like *Plato* and *Ptolemäus* can only be satisfactorily explained by the existence of low-lying exhalations hanging over and obscuring them. Nothing short of an exhaustive study of the interiors of walled-plains of this type, involving careful measurements and alignments of the objects detected thereon, will solve this problem of lunar physics.

With respect to the coarser features, such as wide valleys, passes, depressions, landscapes, etc., etc., which are very generally found in connection with the great walled-plains, much more is required to be known about them and their relation to the border with which they are associated. We want, in short, to obtain as accurate an idea as possible of the structure of these vast circumvallations and some insight into their surface geology (if I may use the expression). Though the value of careful drawings of the shadows of peaks and other objects under different solar altitudes, accompanied by a note of the times when they assumed the form and position shown, has already been briefly referred to, I would again accentuate the importance of this kind of observation. If we possessed, which we do not, except in a few cases, accurate drawings of prominent peaks, it would be quite possible to detect the occurrence of landslips or other catastrophes by changes in the outline and extent of the shadows. Some knowledge of sciagraphy, or the laws which govern the forms of the shadows of objects, will be also found very useful to the lunar observer, and he is advised to experiment for himself on the various shapes which the shadows of objects assume when projected on a plane surface. It will then become apparent that very erroneous conclusions as to the actual form and altitude of lunar peaks, etc., are often drawn from a want of thought on this matter. Another point in this connection is not unfrequently overlooked, *viz:* That the form and extent of a shadow is not only determined by the object to which it is due, but also by the shape and inclination of the surface on which it falls. This is very important to be borne in mind with respect to the Moon, though it is often ignored as a factor in dealing with lunar shadow measurements.

Maria: There is ample scope for useful work in connection with these monotonous, dark regions, which has not, as yet, been attempted systematically, except in the case of the *Mare Seren-*

itatis, and to a more limited extent in a few other instances. Not only do these so-called "seas" include many craters and depressions, large and small, deserving careful scrutiny, but they exhibit differences of tint under various angles of illumination, not apparently due to variations in the solar altitude, which call for sustained investigation. Any good achromatic of from 3-in. to 4-in. in aperture, or reflectors of equivalent capacity, may do good service in this branch of selenography, though it must be confessed that in the absence of some satisfactory standard, free from the liability to physiological errors, tint observations are involved in some difficulty. The employment of an eye-piece, similar to that employed by DAWES for solar observation, so as to minimize the possible effects due to extraneous light, might, as suggested by PROCTOR, be tried to advantage, but an equally pressing requirement is an invariable and absolute scale of tints, and this is, unfortunately, not as yet forthcoming. Under a high light and good definition, some of the *Maria* seem to be covered with innumerable bright points and a network of silvery streaks of great delicacy, which have apparently no relation to objects visible in the same situations at other phases. Perhaps close investigation might tend to explain these phenomena. Other regions display decided traces of color, other than the various shades of grey which characterize the general surface of the *Maria*. Then there are the ridges which are found in all the "seas," and which, in many instances, seem to bear a definite relation to their borders (being more or less concentric with them) and to be physically associated with the small craters on their flanks and summits. Observers very indifferently furnished may do good service in studying these ridges from the time they are first illumined by the lunar morning sun till they are barely visible under a higher light. It is hardly necessary to specify any special objects of this class, as they are so numerous that the observer may easily choose some particular ridge, or group of ridges, for scrutiny, but those in the *Mare Humorum*, in the neighborhood of *Kepler* and *Marius*, in the *Mare Procellarum*, and in the *Mare Serenitatis* are especially noteworthy. Certain obscure rings, having the form and other characteristics of ring-plains, but lacking their brightness, and being scarcely distinguishable in tone from the surrounding region, may occasionally be detected on the *Maria*. Their borders are so low that they appear like mere scars on the grey surface. The work of cataloguing and describing these somewhat abnormal features would be a useful occupation for the amateur with a moderately large telescope.

Clefts, or Rills: These enigmatical furrows are found in almost every part of the Moon's visible superficies, but more frequently on the floors of large enclosures and close to the borders of the *Maria*, than elsewhere. They vary in length from ten to twelve miles to 300 miles, or even more, as in the case of the great *Sirsalis rill*, near the eastern limb; in width, from 500 yards to a mile and upwards; and their depth, in some instances, has been estimated at 300 or 400 yards. About a quarter of a century ago SCHMIDT catalogued 425 of these features, but it is probable that, if a complete list were now prepared, this number would be doubled, at least. The extreme delicacy of most of these objects necessitates the employment of telescopes which will bear high powers in their examination. Still, good work may be done with a 5 or 6-in. achromatic and a S. O. G. reflector of 8 or 9-in. aperture. A few may be glimpsed with much smaller apertures, as, for example, the fine cleft running from the central mountain of *Petavius* to the southeast wall of this formation, which can be seen under a low sun with a 2-in. achromatic; and the beautiful *Ariadæus* cleft, south of *Julius Cæsar*, which is, as regards its coarser sections, a tolerably easy object in a 3½-in. achromatic; but, as a rule, they require good optical means, a practised eye, and excellent atmospheric conditions to be satisfactorily traced. There is a wide field open to the student here, as there are few rill systems which have been accurately or exhaustively mapped, and a few nights' devotion, even to the best-known groups, generally results in the discovery of additional clefts or of new details in connection with those already known. The *Triesnecker* rills, those on the east side of the *Mare Tranquilitatis*, between *Sabine* and *Maclear;* the system round *Ramsden;* those between *Gassendi*, *Mersenius* and *Cavendish*, may be mentioned as groups which require mapping on a large scale and cataloguing. As features of a somewhat similar type, the "faults" in various parts of the lunar surface deserve attention from the observer. The well-known "railroad" (so striking an object under a low sun east of *Thebit*), is the most noteworthy example, but there are many others of a less imposing character. In some cases they are apt to be confounded with straight ridges, and in others (as, for example, the fault which crosses the floor of *Plato* obliquely from N. W. to S. E.), they are only traced with difficulty, even under the most favorable circumstances. Very often the apparent dislocation of the wall of a formation on opposite sides points (as in the case of *Plato*) to the existence of a fault. *Helicon*, a small ring-plain in the *Mare Imbrium*, is also a remarkable example of faulting, well deserving of examination at lunar sunrise.

Ray Systems and Nimbi: Besides the light markings on the floor of certain formations, such as *Plato*, *Archimedes*, *Ptolemäus*, and many others, which not only require considerable excellence in the telescope used and exceptionally good definition, but also, as before remarked, an educated eye to trace them effectually, there are the well-known ray systems and nimbi, which may be studied under much less rigorous conditions. *Tycho*, *Copernicus*, *Kepler*, *Anaxagoras*, *Aristarchus*, *Olbers*, *Byrgius A*, *Zuchius*, *Autolychus*, *Aristillus*, *Proclus*, *Timocharis*, *Furnelius A* and *Menelaus*, are among the most interesting formations exhibiting these phenomena.

There is yet another matter to which the beginner may turn his attention, which has been strangely neglected by selenographers, *viz:* The portraiture of mountains and valleys when seen in outline on the Moon's limb. Accurate sketches of these would be of great interest and value, but they require considerable magnifying power, and involve micrometrical measurements for the purpose of subsequent identification. Still, something may be accomplished without such aids, provided, as is not unfrequently the case, the mountains delineated are in close contiguity with known objects. In making limb observations the observer should be on the watch for abnormal outlines, as, for example, the flattenings detected some years ago by the Rev. H. COOPER KEY on the western limb. These, instead of being arcs of a circle, form straight sections, like the sides of a polygon.

In conclusion, the beginner is advised to keep a very open mind as regards the physical constitution of the Moon. Preconceived notions are often apt to bias observations and to warp the judgment. It is far better to enter on selenographical work untrammelled by theoretical cobwebs, and intent only on faithfully recording whatever is observed. A short spell of patient, systematic observation will teach the observer to estimate the value of current hypotheses and will satisfy him that a very much more intimate acquaintance with lunar details is needed before many vexed questions, relating to the actual condition of the Moon's surface, or its history in the past, can be regarded as approaching solution.

A FEW HINTS TO BEGINNERS IN SOLAR OBSERVATION.

By Miss E. Brown.*

In these days of widespread interest in astronomy there are, probably, many readers of popular essays, or of scientific magazines, who would gladly pass from the ranks of mere readers into those of actual workers, but who are deterred from making the first plunge by the impression that to the inexperienced beginner the accomplishment of any useful work is an almost hopeless aim; that to enroll themselves among real observers needs not only courage and confidence, but technical skill, or mathematical knowledge; and they probably feel that the mere play-work of an amateur, taken up and laid aside on the spur of the moment, and without definite object, will retain but a slender hold on their interest.

It is to such that I venture to offer a few words, based on personal experience, to show how a beginner *may*, from very small beginnings, if only he possess the two most necessary qualifications—accuracy and perseverance, attain to be ranked among those whose work will be welcomed and accepted by the greater scientific lights as a really useful contribution to astronomical knowledge.

When I first took up solar work, I possessed no observatory and no equatorially mounted telescope. I had only an old refractor, of 3-inch aperture, which had already seen a good deal of service, and which I used chiefly for a very elementary study of the Moon and planets, in accordance with the advice of the Rev. T. W. Webb, in his "*Celestial Objects for Common Telescopes*," to avoid looking at the sun "until hand and eye had acquired experience elsewhere."

It was a description given in "Proctor's Half Hours with the Telescope," of a method of observing sun-spots by projection, that induced me, a little later, to take up systematically that

* Cirencester, England.

special line. For this a portable wooden frame was necessary, so constructed as to fit firmly into a small window. To the four sides of this frame were nailed triangular pieces of black calico of sufficient length to allow of the ends being wrapped round the tube of the telescope and fastened there by means of an elastic band, so as to exclude all light.

Dark glasses, which are risky things for the eyesight, were not necessary. A sheet of white cardboard placed on an easel at a suitable distance from the telescope—a yard is a good distance for a 3-inch telescope—formed the medium of projection, and, before darkening the room, the shadow of the telescope tube could, by a little shifting, be easily made to fall circularly upon it.

I shall not soon forget the delight with which, having completed this simple arrangement, I first saw, clear and sharp, the sun's image appear upon the cardboard screen, and noticed upon this image a few little dark spots, which I at once recognized as sun-spots, because, when the tube was shifted and the image of the sun moved, they also moved with it, which would not have been the case had they been merely specks of dust on the lens.

I may add that window curtains, if sufficiently dark and thick, will answer the purpose nearly as well as the above-mentioned apparatus. They must be pinned above and below the instrument, and a large square piece of cardboard, or of brown paper, must be slipped over the eye-piece by means of a small round hole, to shut out any interstices of light, but the necessity of darkening the room only applies to small telescopes. This, my first observation of sun-spots, took place when a minimum period of the sun-spot cycle was approaching, so that there were but few, often not any at all, to excite my interest, but, whether few or many, I at once began to sketch them in pencil whenever they appeared, preserving my sketches in a copy-book, and always marking the dates. One day I was showing these drawings to a friend, when it was suggested to me that I might send some of them to the Greenwich Observatory for inspection. This suggestion I ventured to carry out, and in a very kind letter received from Mr. W. H. M. Christie (now our Astronomer Royal), obtained the great encouragement of his friendly opinion that my drawings really would be useful for comparison with the photographs taken at Greenwich, and for a time I sent tracings of them to him regularly. Mr. Christie told me that the value of a series of drawing of sun-spots depended very much on the regularity with which they were made, and on the length of time over which they extended. He also laid special stress on the desirability of their position on the Sun's disc being correctly indicated, as, without this, in the frequent case of several groups being visible at the same time, their identification would be difficult.

Having at that time no equatorial, I was unable to carry out this injunction, although I did manage to show the relative positions of different groups in a rough way in my sketch-book. Moreover, when you have to be constantly shifting a telescope up or down, according to the sun's varying altitude, and moving it eastward on the screen to keep the image in the field—the difficulty of correct position-drawing is immensely increased. Even cross wires over the eye-piece will not help you much. It is true that if observations could invariably be made at noon, it would be comparatively easy, but this, in our changeful climate, is most uncertain. Thus, to continue the record of my early experiences, time went on, but the maximum period had well nigh passed before I attained to the second and better furnished stage of my astronomical life, which made me the happy possessor of not only an equatorial, but of a little BERTHEN Observatory wherein to house it; and with which possessions came the greatly needed means of correct measurements of sun-spots. A kind friend, Professor THOMSON, who had been my chief helper in the adjustments of my new telescope, began at this time to seriously consider the possibility of devising some simple and reliable plan for the purpose, and the result of this was his invention of the now widely used "THOMSON'S Cardboard Discs," which have Mr. E. W. MAUNDER'S authority for giving the heliographic latitude and longitude to within one degree. These discs are four in number, three of them being reversible, thus forming, in a small compass, the seven discs required to correspond with the seven different positions of the solar axis as seen from the earth at different times of the year, the few necessary calculations of position being obtainable from the Ephemeris for Physical Observations of the Sun in the "*Companion to the Observatory.*" * To use these discs the best plan is to have a light frame which can be attached, with rods, to the eye-end of the telescope, at such a distance as to make the sun's image coincide exactly with the circle of the disc. To compute the areas of sun-spots, which can be done

* The A. S. P. possesses a set of these discs.

with any telescope, paper ruled in squares with four divisions to the inch, is very useful and convenient, and by reducing the projected image of the sun to a circle eight inches in diameter (the size of the cardboard discs), the value of each of these small divisions will be nearly 61″ of arc, or 27.075 miles in length at the sun's mean diameter; or, what amounts to the same thing, the value of 2° of linear measurement on the equator, as shown on the discs, will be 15.115 miles.

And now, having, if with some unavoidable egotism, as briefly and simply as possible, explained *how* to look at the sun and how we may see whatever is to be seen at any time on his surface, I will, in conclusion, venture to impress one or two maxims on all beginners. In the first place, if you would work to any purpose, expect at the outset, beyond the pleasure of being at work, few definite results; look for no great or stirring discoveries; be prepared for long periods when there will be little or nothing to record; but persevere. Make solar work part of your daily work; draw constantly what you see—to do this alone requires a long-practised eye and hand—note accurately the times of observation; above all things, only draw *what* you see. Faithful drawings from different localities, correctly marked as to date, instrument and powers employed, will be a welcome contribution to the directors of all good observatories. Your own interest will increase year by year. The history of a single group of spots, or faculæ, will have its variations and excitements, and *may* have its distinct scientific value. But remember if "Art is long," Science is slow. It only desires the truth. It waits for it; it finds in patient watching the reward of that satisfaction which all methodical and no desultory work gives. It is worth the labor involved, and the laborer who once begins to cultivate his field will rarely, if ever, leave it in disappointment or disgust.

CIRENCESTER, ENGLAND, February 12, 1891.

THE SOLAR ECLIPSE OF JUNE 6, 1891.

By ORRIN E. HARMON.

The writer has computed the phases of this eclipse for four different places in the State of Washington, as follows: Olympia, Blaine, Walla Walla and Spokane Falls.

These places are situated so that predictions for them will serve to give a correct idea of the phases of the eclipse for the State generally.

The duration of the eclipse throughout the State is about $1^h\ 50^m$, except at Blaine, where it lasts $1^h\ 53^m$.

The general phases are as follows:

	BEGINS.	ENDS.
Olympia, -	$6^h\ 21^m\ 45^s$	$8^h\ 12^m\ 02^s$
Blaine, - -	$6^h\ 22^m\ 44^s$	$8^h\ 16^m\ 28^s$
Spokane Falls,	$6^h\ 24^m\ 34^s$	$8^h\ 14^m\ 56^s$
Walla Walla,	$6^h\ 19^m\ 41^s$	$8^h\ 10^m\ 19^s$

These results are given in Pacific Standard Time, and the latitudes and longitudes of the several places were assumed to be as follows:

	LATITUDE.	LONGITUDE.
Olympia, -	47° 00′	$8^h\ 11^m\ 40^s$
Blaine, - -	49° 00′	$8^h\ 11^m\ 00^s$
Spokane Falls,	47° 40′	$7^h\ 49^m\ 40^s$
Walla Walla,	46° 00′	$7^h\ 53^m\ 20^s$

The magnitude of the eclipse is as follows, the sun's diameter being taken at unity:

Olympia, - .51; Blaine, - .55;
Spokane Falls, .47; Walla Walla, .47.

These calculations were made by taking out the places of the sun and moon for some assumed time, supposed to be within a few minutes of the beginning and ending of the eclipse. The primary rule to take out the places of the sun and moon for the hours immediately before and after the time of conjunction, does not hold well in this case on account of the moon's large parallax in right ascension. The moon's hour angle being about six hours at the time of beginning, the parallax throws the moon's apparent place east of the sun's at this time; and the relative path of the moon across the sun's disc thus deduced, will be quite inaccurate. But by taking out the places of the sun and moon for 2^h and 4^h, Greenwich mean time, and computing the parallaxes in R. A. and Dec. for these hours, the moon's path, and consequently the time of beginning and ending of the eclipse, can be quite accurately deduced for any Pacific Coast Meridian. In the above cases the selected times for calculating the moon's path were $2^h\ 21^m$ and $4^h\ 12^m$, Greenwich mean time, this being very nearly the times of beginning and ending for Olympia.

The writer also computed the phases of this eclipse for Mt. Hamilton, California, by the above method, with the following results, in Pacific standard time:

Begins, 6^h 09^m 41^s, A. M.
Ends, 7^h 46^m 54^s, A. M.

CHEHALIS, LEWIS COUNTY, WASHINGTON, March 14, 1891.

ON THE THERMOMETRIC CHRONOMETER OF THE LICK OBSERVATORY.

BY A. O. LEUSCHNER.

The so-called thermometric chronometer (C. FRODSHAM & Co., 0008), of the Lick Observatory, is neither always a sidereal chronometer, nor does it always give mean solar time. It differs from other chronometers, inasmuch as it has no compensation whatever. Accordingly, the slightest change of temperature will produce a perceptible change in its daily rate. In February, 1889, when the first determinations of the rate of this chronometer were made for the purpose of finding its temperature coefficient, it gained on mean solar time in the neighborhood of six minutes per day, or about two minutes on sidereal time. In June, however, owing to the gradual increase in temperature, it was *losing* on sidereal time about three minutes per day. At this point the observations were discontinued, as the material on hand was deemed sufficient for the purpose of finding the temperature-coefficient.

I shall not here attempt to give a complete discussion of the investigations, for the final results have not, as yet, been attained, but, complying with a request of Professor HOLDEN, who thinks that the members of our Society may be interested to learn something about the odd behavior of uncompensated chronometers, I shall roughly sketch the nature of the preliminary reductions, and state the approximate results thereby obtained.

As it happened that during the winter just passed I had to conduct the practical exercises of a class in "Least Squares," I thought that the class might profit by a reduction of my observations, although there are other and simpler methods, by means of which approximations to the temperature-coefficient might have been obtained. In order to learn, at the same time, something about the nature of the time-factor and about that of the barometer-coefficient, it was found expedient, to immediately start with the equations of condition in the well-known form proposed by M. IVON VILLARCEAU:

$$R = R_0 + a\,[T - T_0] + b\,[t - t_0] + c\,[B - B_0] + \ldots,$$

powers beyond the first being neglected; where $\left\{ \begin{matrix} R \\ R_0 \end{matrix} \right\}$ = mean daily rate at the time $\left\{ \begin{matrix} T \\ T_0 \end{matrix} \right\}$ at a temperature of $\left\{ \begin{matrix} t \\ t_0 \end{matrix} \right\}$ degrees (Celsius) and at a pressure of $\left\{ \begin{matrix} B \\ B_0 \end{matrix} \right\}$ $\frac{1}{10}$ inches,

a = the time-factor,

b = the temperature-coefficient,

c = the barometer-coefficient.

R, T, t and B being observed quantities, four normal equations had to be formed for the determination of the unknown quantities R_0, a, b and c.

As the observations extended through nearly four months, and as the number of equations of condition that can be formed from comparisons on N successive days is (N—1), it would have been too laborious a task for each one of the beginners to carry out the entire problem (normal rates not having been formed before hand). The material was, therefore, divided into groups of from ten to fifteen days each, and the groups then divided among the students. Thus each computer obtained the four constants, independently of the others.

Before making known the results it may be well to shortly state, how in the equations of condition the terms t and B were formed, as it then will become apparent why the results obtained by this reduction cannot be considered to be final. At the Lick Observatory, as at many other stations where meteorological observations are made, the mean daily temperature is obtained by taking one-fourth of the sum of the thermometer readings made at 7 A. M., 2 P. M., and twice that made at 9 A. M. The chronometer comparisons were made at 12 A. M., and the rate was taken from one day noon to noon of the next day. Thus the daily rate depended on the temperatures of two days. It is evident that the rate was independent of the 7 A. M. reading of the first day and of the 9 P. M. reading of the second. By recombining, however, the different readings of the two days, quite accurate mean temperatures for the interval through which the rate extended might have been formed. But, for the purpose in hand, it was thought sufficient to simply consider the algebraical mean of the mean temperatures of the two days between which the rate was taken as the temperature on which the rate depended. In general, this device has answered exceedingly well, though some cases occurred in which *a priori* a first-class representation could not be expected. Thus—to take an extreme case—if the mean daily temperatures of three successive days had been 1) 50° 2), 40° 3), 50°, the temperature corresponding to the rate from the first to the second day would have been 45°, and that from the second to the third would have been the same, so that part of the effect of the sudden changes in temperature would have been lost by this combination. On examination it was found that all the larger residuals could be explained from this, or similar circumstances. The same remarks apply to the formation of the term B.

The time-factor and barometer-coefficient are, in most chronometers, very small, in some cases hardly appreciable.

From an investigation of several chronometers Dr. J. HILFIKER (*l'influence de la pression de l'air sur la marche des chronomètres, extract du bulletin de la société des sciences naturelles de Neuchâtel, tome xvii*) finds the barometer-coefficient to vary from $-0^s.01$ to $+0.04$ per $\frac{1}{10}$ inch. Although the average time-factor in our case was found to be comparatively small, it is clear from the manner in which t and B were formed that the results obtained for a and c must be extremely uncertain. The chief object of the preliminary reductions, however, namely, the approximate determination of the temperature-coefficient, has been very satisfactorily attained. It was found that *the rate of the chronometer changes* $16^s.2$ *during one day, if the temperature changes one degree during the same interval.* It may be interesting to compare this result with others, as, for example, with those M. GUSTAVE CELLÉRIER (*étude numérique des concours de compensation de chronomètres, etc., mémoires de la société de physique et d'histoire naturelle de Genève, tome xxix,*) who has made extensive investigations in this connection. The temperature-coefficients given by him for various chronometers range between 9^s and 10^s. These rates of uncompensated chronometers are extremely large, and our greatest admiration is due to the skillful inventors who, by proper compensation, have been able to reduce the rates to quantities which are insensible as compared with the foregoing.

On the hypothesis that our chronometer is a sidereal chronometer, the zero-point—i. e., the temperature for which the chronometer has no rate whatever, places itself at 54°.7. Accordingly, if we consider the chronometer to give mean solar time, the zero-point will be 69°.2. I reserve a more complete discussion to some future time, when the final results shall have been attained.

BERKELEY, CAL., March, 1891.

THE SYSTEM OF THE STARS.*

BY GEORGE E. HALE.

The rise and progress of Stellar Astronomy have been so rapid that, of necessity, its literature is almost wholly confined to the papers scattered through the publications of observatories and the various astronomical journals. It is, therefore, pleasant to find a large amount of this material collected together into a single volume, and entertainingly woven into a connected narrative. There are few observations or theories of importance within the range of her work which Miss CLERKE has not touched upon, and, though at times she rather summarily dismisses views at variance with her own, it may be said, in general, that opinions of any weight are accorded reasonable recognition. The plan of the book is to lead by gradual steps from the individual to the general, passing from single stars and nebulæ to double and multiple systems, and reaching, finally, the crowning problem of the construction of the heavens.

The first chapter brings forcibly before the mind the unbounded scope of astronomical investigation in a general account of the number and distribution of the stars, and devotes, in passing, considerable space to an explanation of scintillation. In the second chapter the methods of research are briefly pointed out, and the recent important developments of stellar photometry, photography and spectroscopy are clearly described. "Sirian and Solar Stars" form the subject of the third chapter, and here we are

* *The System of the Stars*; by Miss AGNES M. CLERKE, London, 1890, 8vo.

introduced to a theory, proposed by Miss CLERKE, to account for the atmospheric conditions of these numerous bodies.

From the early days of stellar spectroscopy to the present, the stars of SECCHI'S first type have been considered to represent the maximum limit of temperature among the heavenly bodies, and the peculiarities of their spectra are supposed to depend upon this high degree of heat. Characterized as they are by the prominent absorption lines of hydrogen in the ultra-violet, they are connected with the solar stars by intermediate bodies in which "the conspicuousness of rays due to absorption by ordinary metals * * * varies inversely with that of the hydrogen series" (p. 42). But some stars, while possessing an ultra-violet spectrum which entitles them to a place between *Sirius* and the sun, exhibit certain marked peculiarities. These constitute SCHEINER'S Class I b, which includes *β Orionis*, *ε Orionis* and *α Cygni*. Their spectra contain comparatively few lines in the visible portion, while in the blue, violet and ultra-violet the numerous lines are all of about equal width, though their intensities are very different, the hydrogen series in *α Cygni* standing out prominently on the HARVARD photographs from a background of fainter lines. Dr. SCHEINER has shown that the spectrum of this star has very little similarity with that of the sun, for although a large number of iron lines agree fairly in position, the force of these coincidences is greatly decreased by the remarkable differences in intensity.* Miss CLERKE has been criticised for classing these with *Sirian* stars† on the ground that the nature of the "Orion stars" must be influenced by the presence of the nebulæ, but her critic seems to have overlooked the fact that she follows Dr. SCHEINER in placing *α Cygni* with the "Orion Stars," and in this case his reason for separate classification does not hold. If Mr. FOWLER would refer to Dr. SCHEINER'S description and measures of the spectrum of *α Aquilæ*, he would find that the author places it, with good reason, nearly midway between *Sirian* and solar stars. Although it is by no means impossible that solar stars should be divided into two groups, on the basis of increasing or decreasing temperature, the separation indicated by Mr. FOWLER is evidently not free from objections.

It should be noted on p. 44 that AMES has found the fifth

* Scheiner Die Spectralanalyse der Gestirne, p. 272.

† Nature, December 25, 1890.

hydrogen line (near H) to be absent from the solar spectrum,* and it might also be mentioned here that a mistake is made on p. 38, in the statement that CORNU obtained the entire hydrogen series, for the tables in the paper referred to do not contain the very last line of the series. It is an interesting fact that AMES was unable, under any conditions, to obtain the "Stellar Series" without the "secondary" spectrum investigated by HASSELBERG.†

Miss CLERKE rightly gives prominence to the value of conclusions drawn from the appearance of the K line in stellar spectra, but the immediate application to her theory of electrical repulsion can hardly be so easily allowed. In the first place, as will be shown more in detail in a subsequent paper, the statement that "so far as terrestrial experiments can inform us, it (the substance emitting both H and K) arises as a modification of the metal calcium only under the strongest electrical excitement," on p. 45, is incorrect, for I have recently photographed both lines at the temperature of burning magnesium wire, and photographs of the spectrum of calcium chlorides in the BUNSEN flame, probably, also show both of them faintly. It is true that they are not strongly developed under these conditions, but it is, at the same time, evident that the calcium molecule, as it exists in the flame, does not require to be dissociated to produce the lines in question. The variations in the intensity of H and K are entirely analogous to the variations of the blue calcium line at $\lambda 4226.3$, and in this case we know that the greatest intensity does not correspond with the strongest electrical excitement, for the intensity reaches a maximum in the electric arc, and is decreased with an increase of the current. At the high temperature of the high tension electric spark the intensity is still further decreased, and in the solar spectrum the blue line is of small importance as compared with H and K. It seems very probable that the intensity changes of H and K can be traced almost entirely to conditions of temperature, though the secondary effect of electricity is not necessarily excluded. These lines are weak at low temperatures, but increase steadily in strength up to their maximum development in *Arcturus*. Further increase of temperature acts with them as with the blue line in the arc, until it seems possible, although contrary to the belief of Professor LOCK-

* Phil. Mag. [5], v. 30, No. 182, p. 54.

† Ibid, p. 52.

YER and others, that H may have about the same strength as K in the hottest stars, but appears broader and more intense on account of the overlying hydrogen line. This last point is, however, of little importance here, and we may consider with Miss CLERKE only the K line. It will be seen that from this point of view there is little argument for her theory that the *Sirian* stars are developed from solar stars by a decrease of the electrical repulsion in their atmospheres, and a consequent precipitation of the heavier constituents to the level of the photosphere. A single case will show that reasoning, based on the strength of K, must be fallacious. On p. 48 *Arcturus* is shown to be at a higher temperature than the sun by the presence in its spectrum of six out of the nine lines in the ultra-violet hydrogen series. This would give it a place between *Sirius* and the sun, and, on Miss CLERKE'S theory, the electrical repulsion in the atmosphere would be less than that in the surroundings of the sun. But the author also supposes the electrical repulsion to be directly proportional to the strength of K, and K in *Arcturus* is even more prominent than the same line in the sun (p. 47); thus the results reached from the two points of view directly contradict each other.

The arguments brought forward by Dr. HUGGINS in his Bakerian lecture on the corona* are strongly in support of an electrical repulsion acting outward from the sun, but in using a similar view to account for the phenomena of stars of different types, Miss CLERKE holds only the one fact of an electrical repulsion in common with Dr. HUGGINS. The latter, from his long and varied experience in stellar and solar spectroscopy, believes that the sun is reducing its temperature; that the electrical repulsion increases with an increased activity on the surface, and was, consequently, greater at the higher temperature of the Sun, in early geological times.† Miss CLERKE, on the contrary, holds that the sun is increasing in temperature, and that the electrical repulsion decreases as the temperature increases. As the former view is in direct opposition to the belief of most of the best solar physicists, and as the latter contradicts the author of the theory on which it is based, it will be admitted that the electrical theory of the stars must be regarded with some degree of hesitation. The electrical theory has many points in common with the views of Mr. G. J. STONEY, referred to in the text (p. 50), and the question of vapor

* Proc. R. S., No. 239, p. 108.

† Loc. cit., p. 134.

density occupies about the same position in both cases. So far as the *Sirian* stars are concerned, the identification of the less prominent lines with lines of iron, sodium, calcium and magnesium is exactly what Dr. STONEY,* and, probably Miss CLERKE, as well, were led to expect from a consideration of the probable vapor densities of these metals. But it may be noted that most of these same metals have been among the first recognized in stars of SECCHI'S second and third types, as well as in the first.

Leaving, for a time, this portion of the problem of stellar evolution, let us turn our attention to the discussion of stars with banded spectra given in Chapter IV. Starting out with an exalted scale of temperature in mind, the statement on p. 52 that "isolated rays of definite wave-lengths, forming in the spectrum what we call 'lines,' bright or dark, are emitted only at very high temperatures," is a curious one to every reader who knows the low degree of heat necessary to bring out lines in the spectra of many substances. Such statements as this could hardly mislead, but more attention should be paid to accuracy, especially when about to take up the difficult and important subject of the red stars.

The investigations of HUGGINS, VOGEL and DUNÉR on the visual, and of PICKERING and SCHEINER on the photographic spectra of the third type stars have shown that beneath a strongly marked system of absorption flutings a line spectrum is undoubtedly present, which is so similar to the solar spectrum that there can be little doubt but that one type results from the other by some process of evolution. A marked peculiarity of third type spectra is in the fact that several of the flutings are terminated by sharp, metallic lines, and for this no explanation has yet been offered. Dr. SCHEINER has also found that many lines are hazy on one side and sharp on the other, and whatever may be its cause, this appearance is certainly very similar to that of the individual lines in the flutings of some metallic oxides. There can be no question but that the third type spectra are strongly indicative of a comparatively low temperature. Whether, as Miss CLERKE would have us believe, the photosphere is about of the same degree of heat as the photosphere of our sun, while the fluting absorption takes place in the cooler regions of a very extensive atmosphere, cannot as yet be definitely answered, but our author brings forward some excellent reasons in support of such a view.

* Proc. R. S , v. 17, p. 50.

The fact that absorbing calcium lies above radiating hydrogen in *Mira Ceti* is well illustrated in an excellent reproduction of a DRAPER Memorial photograph of the spectrum of this star. The exponents of the meteoritic hypothesis find it very difficult to account for this condition of things, and, in fact, a careful consideration of third type spectra does not lead one to the belief that they can all be accounted for by the collisions of meteor swarms. On the contrary, as Dr. SCHEINER has remarked in his recent work, the greater the accuracy brought to bear in a study of this hypothesis, the more untenable do its foundation principles become. Mr. FOWLER has complained because of Miss CLERKE'S failure to mention a few observations which go to prove the presence of certain of the bright carbon flutings in the spectra of *α Herculis*, *Mira Ceti* and *Nova Orionis*, and perhaps these should have been alluded to. But it is admittedly true that in the great majority of the third type stars the difficulty of demonstrating the presence of bright carbon is almost, if not quite, insuperble, whether the reasoning be based on the effects of masking and contrast, or on actual comparisons with high dispersion at the telescope. Professor LOCKYER has explained that the "three figure notation" used in his earlier publication was merely provisional, and if the hypothesis is to stand, it must admit of measures comparable in accuracy with those demanded in solar work. In the case of the much-discussed chief nebular line such measures have been made, and the result is a high improbability that magnesium, whether free or in combination, is responsible for the line. In other words, the first serious attack upon the hypothesis has served to weaken it, and the recent work of Dr. and Mrs. HUGGINS on the WOLF-RAYET stars in *Cygnus* is another step in the same direction.

If third type stars are, in reality, characterised by great atmospheric extension, the electrical repulsion theory offered by Miss CLERKE seems to supply a possible explanation, but its probability is open to considerable question. Dr. SCHEINER has referred to a marked similarity between third type and sun-spot spectra, and finds a possible explanation of variability on this basis. But, in spite of the great mass of information already gathered in regard to stellar spectra, the dispersion has been so low in almost all cases that it seems best to defer judgment until greater certainty is secured in a far more comprehensive investigation than has yet been undertaken. It cannot fail to be noted that the majority of the best spectroscopists are extremely conservative, and few of them hazard a general explanation of the complicated problem, whose great extent they so fully realize.

The faintness in fourth type stars is so great a hindrance to spectroscopic investigation that, as yet, the secondary elements of their spectra are but little known. The few lines measured point to a probability of iron, but nothing is thoroughly well known about these stars, except the certain presence of carbon, as signified by its strongly marked absorption flutings. Dr. SCHEINER gives a few lines which seem to be common to α *Orionis* and the fourth type stars, and on the strength of this he believes that SECCHI's third and fourth types should not be completely set apart, but classed as subdivisions of the same type, the marked differences in their spectra being brought about by unexplained differences in the chemical combinations in their atmospheres.* But, if we except a single doubtful instance of little weight, there seem to be no examples of stars marking the transition stage from the second to the fourth type, while the second and third are clearly connected. Mr. FOWLER urges a suggestion of Professor LOCKYER'S that the secondary lines in the fourth type are indicative of such absorption as take place in our own atmosphere, and cites the presence of carbon in the sun to connect the fourth type with solar stars, assigning a lower position to the former on the descending branch of the temperature curve. Miss CLERKE believes that the strong absorption in fourth type stars is accompanied by "imperfect condensation" in an atmosphere of great depth, while the photosphere is in a state of "powerful incandescence" (p. 64). She does not use her electrical theory to account for this peculiar class of bodies, and wisely omits a speculative discussion of their origin.

In Chapter V we come to what may probably be called the most interesting field of spectroscopic astronomy—the gaseous stars and nebulæ. In the explanation of stellar bright lines Miss CLERKE is decidedly opposed to the view of Dr. SCHEINER that they result from the fact that the radiations from "enormous self-luminous atmospheres" would "predominate simply through quantitative excess over the continuous radiance of comparatively small nuclei." While Dr. SCHEINER believes in an increased absorption of hydrogen in the denser strata near the photosphere of γ *Cassiopeiæ*, the author urges that "the fineness of other dark

* *Spec. der Gestirne*, p. 321.

lines in the same spectrum implies an atmosphere tenuous throughout" (p. 64), though on the next page Professor PICKERING'S discovery of the double reversal of the hydrogen lines in *Pleione* is mentioned, with the remark that "an absorbing stratum is placed beneath a more vividly incandescent bed of the same substance, and the condition partially indicated in γ *Cassiopeiæ* is fully attained." The peculiarity in this condition of things lies in the fact that *Pleione* is usually classed in the first type, and, although a denser stratum of hydrogen near the photosphere is thus rendered probable, it is by no means easy to draw a general conclusion applicable to third type stars. As calcium is known to lie above the brilliant hydrogen in *Mira Ceti*, the elements producing the "other dark lines" may, in some similar way, be without the region of greater pressure. It is next stated that "the phenomena of spectral variability appear entirely inconsistent with this rationale. Fluctuations in atmospheric extent, even if we could admit their occurrence on the incredible scale and with the incredible swiftness required, would not account for the *relative* variability of bright lines." It is posssible that fluctuations in atmospheric extent are not involved in spectral variability, but the changes in spectra must be much better known than at present, before they can be used as an argument on either side of the question. The last objection offered by Miss CLERKE against Dr. SCHEINER'S view, is in the great number of bright lines found by Dr. BECKER in the spectrum of β *Lyræ*. The alleged difficulty is, that an atmosphere of such "heterogeneous constitution" could not rise to so great an elevation above the photosphere. (p. 68.) But, with increased skill in the method of attack, the spectrum of the *Orion* nebulæ has been found to be more and more complicated, the complexity of bright lines originating at enormous distances from the probable center of condensation in the trapezium. Here, then, is an atmosphere of complex constitution, rising to altitudes far greater than any required by Dr. SCHEINER, and, though condensation is evidently further advanced in β *Lyræ*, there may still remain an extensive and brilliant atmosphere. Nothing can be of greater interest or value than a careful study of the simultaneous variations in the spectrum and light of such a variable as β *Lyræ*. As remarked on page 69, it is not improbable that changes in general absorption are involved, and photometric measures of different parts of the continuous spectrum are, therefore, desirable.

The recent investigations of Dr. and Mrs. HUGGINS have directed renewed attention to the interesting stars of the WOLF-RAYET type. Probably because of the small dispersion of his instrument, Mr. FOWLER found the blue band in the spectrum of the three stars in *Cygnus* to agree exactly in position with the blue band of carbon in the flame, and from this comparison Professor LOCKYER drew his main argument to prove that bright-line stars are "nothing more than swarms of meteorites a little more condensed than those which we know as nebulæ." * But the previous observations of VOGEL could not be reconciled with this view, and the measures and direct comparisons of Dr. and Mrs. HUGGINS were undertaken with considerable dispersion, in order to clear up the question. The result is that the blue band in the four stars observed agrees neither in position nor character with the blue carbon fluting, and as no brightenings in the spectra were detected at the positions of the other carbon bands, there seems to be no reason to believe that carbon exists in the atmospheres of the WOLF-RAYET stars.† The chief argument for the meteoric constitution of these bodies is thus destroyed. Miss CLERKE does not here refer to Professor LOCKYER'S "meteoritic hypothesis," and, for some reason, omits to bring forward her own electrical theory, or any other explanation of bright-line stars of this type.

On page 49 the spectral variations of the "*Orion* stars" are made to connect the first and second types, and it is remarked that "the dividing-line, rendered difficult to draw by the occurrence of intermediate examples, is still further effaced by the swinging across it of a few unstable objects." The statement met with on page 72 expresses a different view. "The brilliant stars of *Orion* may be said to mark the first stage on the road toward nebulosity. For their spectra appear at times unbroken by the traces of hydrogen-absorption, more or less strongly impressed upon them at others; and the transition is an easy one from this state of things to that existing in β *Lyræ*, where the same sort of fluctuating balance of temperature inclines preferentially the other way. That is to say, the hydrogen atmosphere of this star tends to rise above the thermal level of its photosphere. Emissive superiority is substituted for neutrality, and gains more and more the upper hand, as gaseous stars merge into undoubted nebulæ."

* Nature, v. 42, p. 344.

† Sidereal Messenger, February, 1891.

Certainly, the line of evolution indicated in the two cases is markedly different, and the author seems to be open to the charge of inconsistency, urged on the same point by Mr. FOWLER.

The account given by Dr. HUGGINS of his observations of the spectrum of Comet I, 1866, seems to indicate that no very elaborate precautions were taken to insure great accuracy, and, indeed, the low degree of dispersion would have rendered them useless.* But whether the chief nebular line was present or not, there seems to be some reason to believe that comets and nebulæ are in some way related. Even if a very intimate relationship were assumed, however, it is by no means proved that nebulæ are the visible results of the collisions of swarms of meteorites, for it is not even yet proved satisfactorily that comets are of meteoric nature. The long and laborious investigations of nebular spectra which have been carried on by Professor LOCKYER, Dr. HUGGINS, Mr. KEELER and others, have resulted in valuable negative evidence, though we are, as yet, entirely in the dark as to the true origin of the principal line. Miss CLERKE concludes (p. 77) that the nebulæ "are not greatly heated," and, in this respect, she is in general agreement with Professor LOCKYER. But, on this view, how is the presence of α and β of the hydrogen series in the *Orion* nebulæ to be accounted for? (Is not the note at the foot of page 78, stating that the "entire series" was photographed by Dr. and Mrs. HUGGINS, incorrect?) It seems probable that a considerable degree of heat, or electrical excitement, is necessary to the production of any of the lines in the ultra-violet series, and Dr. and Mrs. HUGGINS believe that the nebulæ "consists probably of gas at a high temperature and very tenuous, where chemical dissociation exists, and the constituents of the mass, doubtless, are arranged in the order of vapor-density.† The pressure of the D_3 line, found only in the very hottest regions of the sun, is of the greatest importance in this connection. In her review of the present volume Mrs. HUGGINS has stated that recent investigations on the *Andromeda* nebula show that the continuous spectrum does not end abruptly in the orange, as stated on page 81, but fades away gradually into the red. As remarked, at the close of the chapter, there are undoubtedly great possibilities in future investigations of the apparently "continuous" spectra of the nebulæ.

* Proc. R. S., v. 15, p. 5.

† Proc. R. S., v. 46, p. 59.

The belief has long been held that stars are evolved in the lapse of ages, from the elementary condition of the nebulæ, but striking proofs were lacking until very recently. Perhaps no two things could bring the subject more forcibly to our attention than Mr. ROBERT'S magnificent photograph of the *Andromeda* nebula, and the discovery of Dr. and Mrs. HUGGINS that the stars in the trapezium of *Orion* are really in organic connection with the great mass of nebulous matter surrounding them. Here is a foundation upon which to build, and Miss CLERKE is doubtless justified in her remark that "gaseous stars take their rise almost insensibly from planetary nebulæ, and themselves merge into unmistakeable suns," though Professor PICKERING'S distinct separation from all other stars of his fifth type, containing bright-line stars and planetary nebulæ,* shows that the course of development is not yet clear. Many considerations make it probable that if any system of stellar classification is to be of more than merely empirical value, it must start from the condition of the nebulæ, and here the careful grouping of VOGEL is deficient. There are other objections to the same system; for instance, the much-discussed groupings of the third and fourth types. If the line of evolution really divides just after the solar stage is passed, there certainly should be found some example of spectra intermediate between the second and fourth types. Although it was thought by DUNÉR that he had found one such star, its feeble brilliancy allowed no degree of accuracy in the investigation of its spectrum, and no connecting examples are known with sufficient definiteness to afford much ground for argument. Miss CLERKE, indeed, believes that the third and fourth types cannot "be set far apart in the developmental series" (p. 89), but her views are not substantiated by any well-founded arguments, and, for the present, at least, the fourth type stars should probably be considered by themselves. If this is done, of course no complete line of evolution can be developed, for in any system of value no objects of any importance can be left out. But this conclusion is not to be regretted, for a crowd of incomplete and defective hypotheses, though each may point out certain interesting relationships, can bear no comparison in value with a comprehensive scheme of evolution, deliberately and carefully worked out, and embodying the results of the most searching investigation. It is thus best, at present, not to be too positive in statements based upon observa-

* Fourth Annual Report HENRY DRAPER Memorial, p. 8.

tions made with limited or insufficient instrumental means, for future researches are more than likely to show that they are entirely unfounded.

But, although she does not try to cover all the ground, can even the partial line of evolution mapped out by the author be considered of a very satisfactory nature? Starting out with stars of the third type, and pursuing the rising branch of a temperature curve not unlike that of Professor LOCKYER, the solar and *Sirian* stage are successively passed through. The sun is thus supposed to be rising in temperature, the reasoning being based on the belief that atmospheric extent is inversely proportional to age, while the sun is considered to have a less extensive atmosphere than *Sirius*. The electrical theory is once more brought into play, with the conclusion that the sun will be, at some future day, a star like *Vega* or *Castor* (p. 90). Whatever the objections which might be raised against the principles involved in this reasoning, it is safe to agree that "the line of stellar evolution indicated by recent inquiries, is from red stars with banded spectra, through yellow stars with metallic lined spectra, to white stars distinguished by almost exclusive hydrogen atmosphere," if "stars of the third type" be substituted for "red stars with banded spectra" (p. 92). Beyond this, the extensive investigations of Professor E. C. PICKERING show that it is unsafe to go.*

The temperature curve drawn by Miss CLERKE rises easily to the maximum, but, in endeavoring to descend, it seems to meet with serious obstacles. Although it is stated at the opening of the chapter that "among the hosts of heaven we may expect to find * * * stars still effective as radiators, though of declining powers," the author does not find the expectation realized, so far as the spectroscope is concerned, and, in lack of observation, she feels compelled to predict a new spectral type, exemplified by the, as yet unknown, spectrum of the satellite of *Sirius*. "There is a strong probability, however, that the light of the dim component will prove, on analysis, to be of an undistinguished character, interrupted neither by bands nor conspicuous dark lines, and feeble, not through effects of absorption, but intrinsically" (p. 92). It seems strange that, if such a type exists, it has not been discovered in the thousands of photographs and observations of stellar spectra which have been recorded. The probably fatal objections to any such characteristics of the spectra of cooling

* Fourth Annual Report HENRY DRAPER Memorial, p. 8.

stars have been well given by Mr. FOWLER in the review already referred to. The changes of condition incident to the cooling of stars like *Sirius* must be made manifest by gradual changes in spectrum, and in some way the hydrogen lines must disappear. If the "electrical repulsion" were supposed to continue to decrease on the plan already mapped out for it, the line of hydrogen would presumably grow broader and, finally, fainter, while the other lines of the spectrum entirely disappeared. But there seems to be not the slightest reason to believe that this is the case. If, on the other hand, the hydrogen lines became progressively finer, an increased prominence of the metallic lines might be expected. In fact, it is difficult to see anything of value in Miss CLERKE'S hypothetical stellar type, and the downward branch of the temperature curve is still an enigma.

The next three chapters deal with the temporary and variable stars, and one's interest cannot fail to be aroused by a most readable account of these remarkable bodies. From a spectroscopic point of view, the light changes in *Nova Cygni* are most significant, and the ascendancy of the chief nebular line with the decline in brilliancy of the star, must be well taken into account in endeavors to explain the phenomenon. Professor LOCKYER'S meteoric explanation has the great advantage of fitting in with the fact of very rapid cooling, but other considerations show that it is probably safer to replace his postulates of two colliding meteor swarms by the more indefinite phrase, "masses of nebulous matter," or, as Miss CLERKE has done, by a comet and a nebulous star (p. 107). At the same time, a host of other explanations have been brought forward by ZÖLLNER, LÖHSE, WILSING and others, and, though these are not referred to by Miss CLERKE, they deserve some consideration. As is properly urged, it seems more than probable that temporary and variable stars are closely related in nature, and the causes involved cannot presumably be widely different in kind, however wide the separation in degree.

Variables of the *Mira Ceti* type next offer themselves for explanation, and several hypotheses are mentioned. Considerable attention is accorded Professor LOCKYER'S "collision theory," and its good and bad points are impartially pointed out. But no mention is made of the possibility of multiple swarms, with the complicated effects to which they might conceivably give rise, unless an obscure reference on page 127 be excepted. Instead, the author passes rapidly on to develop a theory based on an analogy between the curves of sun-spot frequency and the light changes in variable stars. She believes that "the maximum of spots in the sun corresponds with the maximum of light in stars, and *vice versa.*" Accepting Professor LOCKYER'S theory that sun-spots are due to down-rushes of cooled matter upon the photosphere, she considers that the falls are vastly increased in number at spot-maximums, and the intense heat, accompanied by the development of great electrical force, account for the changes in brilliancy and spectrum. Seemingly, in order to connect this explanation with that given for temporary stars, the spot period is supposed to be controlled by an attendant body revolving in an orbit of dimensions determined by the atmospheric extension of the star. Tidal effect is also hinted at, and it would be a strange chance if this all-embracing explanation did not contain some grains of truth. This, however, does not vitiate the force of the statement that "the time has not come to formulate a theory of stellar variability" (p. 125). As to short-period variables, they seem to offer even greater difficulties than those of longer period, with the exception, of course, of the *Algol* type, which Dr. VOGEL'S spectrographic investigations have fully explained.

The interesting descriptive matter contained in the rest of the book calls for no particular discussion here, but it can be highly recommended as giving a valuable account of the general topics of stellar astronomy. The chapter on the colors of the stars renders very certain the belief that methods of observation much more reliable than those generally employed in the past, must precede conclusions of very great value. Double stars, variable doubles, stellar orbits and multiple stars occupy successive chapters. The *Pleiades* deservedly claim a chapter to themselves, before star clusters in general are taken up, and the results of recent investigation are entertainingly introduced by references to the legendary importance of this celebrated group. The next three chapters are devoted to the nebulæ, and reproductions of Mr. ROBERTS' photographs form excellent illustrations, with the unfortunate exception of the Great Nebula in *Andromeda*, which should have been the best of all. In the discussion of the nature and changes of the nebulæ the importance of the physical analogy between comets and nebulæ is pointed out, and it is insisted that electricity is involved as the illuminating power. This is by no means impossible, but it it hardly time to say that the nebular spectrum "probably includes no element of truly continuous light" (p. 296). The distances of the stars, translation of the solar system, proper motions, the Milky Way, status of the nebulæ and the construction of the heavens, are the subjects treated of in the remaining portion of the work, and there are six valuable tables in the appendix.

In spite of its few defects, Miss CLERKE is to be congratulated upon a book which is excellent in the main. A fair discrimination, combined with a wide range of information and an attractive style, seem to be the chief elements in her deserved success.

KENWOOD PHYSICAL OBSERVATORY,
CHICAGO, March 21, 1891.

BY-LAWS OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC.*

ARTICLE I.

This Society shall be styled the ASTRONOMICAL SOCIETY OF THE PACIFIC. Its object shall be to advance the Science of Astronomy, and to diffuse information concerning it.

ARTICLE II.

This Society shall consist of Active, Life, Corresponding and Honorary members, to be elected by the Board of Directors.

1. Active members shall consist of persons who shall have been elected to membership and shall have paid their dues as hereinafter provided.

2. Life members shall consist of persons who shall have been elected to life membership and shall have paid $50 (fifty dollars) to the Treasurer of the Society.

3. Corresponding members shall consist of persons not residing on the Pacific Coast, who shall have been elected as such.

4. Honorary members shall consist of persons specially distinguished for their attainments in Astronomy, not to exceed thirty in number, who shall have been elected as such.

Corresponding and Honorary members shall pay no dues, shall not be eligible to office, shall have no votes, and shall receive the Publications of the Society.

5. A certain number of Observatories, Academies of Science,

* For the convenience of new members, the By-Laws now in force are here printed.

Astronomical Societies, Institutions of learning, etc., not to exceed one hundred, shall be designated by the Board of Directors as Corresponding Institutions, and they shall receive the Publications of this Society in exchange or otherwise.

ARTICLE III.

At each annual election there shall be elected a Board of eleven Directors, and a Committee on Publication, consisting of three members. The officers of this Society shall be a President, three Vice-Presidents, two Secretaries and a Treasurer. The Directors shall organize immediately after their election, and elect from their number the officers of the Society. They may also appoint a Librarian, and such other assistants as may be required. The Directors shall fill by appointment any vacancies which may occur after the annual election.

The Library of the Society shall be kept in San Francisco, and shall be open to the use of all the members.

ARTICLE IV.

The President, or, in his absence, one of the three Vice-Presidents, or, in the absence of both the President and the Vice-Presidents, any member whom the Society may appoint, shall preside at the meetings of the Society. It shall be the duty of the President to preserve order, to regulate the proceedings of the meetings, and to have a general supervision of the affairs of the Society. The President is *ex-officio* a member of all Committees of the Board of Directors.

ARTICLE V.

The Secretaries shall keep, and have the custody of, the records; they shall have the custody of all other property of the Society, excepting the money thereof; they shall give timely notice of the time and place of meetings; they shall keep in books a neat and accurate record of all orders and proceedings of the Society, and properly index them; they shall conduct the correspondence ot the Society; they shall preserve and index the originals of all communications addressed to the Society; and keep a copy of all their letters, properly indexed; and they shall prepare for publication an accurate summary of the transactions of the Society at each of its meetings.

ARTICLE VI.

The Treasurer shall receive and deposit in such bank as may be designated by the Directors, to the credit of the Society, all donations and bequests of money and all other sums belonging to the Society. He shall keep an account of all money received and paid by him, and at the annual meetings shall render a particular statement of the same to the Society. Money shall be paid by him only on the written order of the Finance Committee of the Board of Directors. He shall give such bonds as may be required by the Board of Directors.

ARTICLE VII.

Candidates for active or life membership may be proposed by any member of the Society to either of the Secretaries, in writing. A list of such candidates shall be certified to the Board of Directors by the Secretaries at each of their meetings, in writing. A majority (not less than three) of the Directors present at any such meeting shall be required for election.

ARTICLE VIII.

Each active member shall pay an annual subscription of five dollars, due on the first of January of each year, in advance. Each active member shall, on his election, pay into the Treasury of this Society the sum of five dollars, which shall be in lieu of the annual subscription to the first of January following his election, and in lieu of an initiation fee. No one shall be deemed an active member, or receive a diploma, until he has signed the register of members, or accepted his election to membership in writing, and paid his dues for the current year. Any member may be released from annual dues by the payment of fifty dollars at one time, and placed on the roll of life members by the vote of the Board of Directors. Any failure on the part of a member to pay his dues within six months after the time the same shall have become payable, shall be considered equivalent to a resignation.

ARTICLE IX.

The annual meeting of this Society shall be held on the last Saturday in March at eight o'clock, P. M., at the rooms of the Society in San Francisco; and meetings shall be held for the ordinary transactions and purposes of the Society, as follows:

Meetings shall be held in the Library of the Lick Observatory, Mount Hamilton, at a suitable hour on the second Saturday of June and the first Saturday of September; and meetings shall be held in the rooms of the Society, in San Francisco, at eight o'clock P. M., on the last Saturdays of January, March and November.

A special meeting may be called by the President, or, in his absence or disability, by one of the Vice-Presidents, or, in the absence or disability of both the President and the Vice-Presidents, by the Secretary, on the written requisition of ten active or life members; and the object of such meeting shall be stated in the notice by which it is called.

The annual election shall be held on the day of the annual meeting, between the hours of 8:15 and 9 P. M.

Only active and life members shall be permitted to vote at any meeting of the Society, and no one shall vote who has not paid all his dues for past and current years. There shall be no voting by proxy.

ARTICLE X.

Fifteen active or life members shall be a quorum for the transaction of business.

ARTICLE XI.

No papers or manuscripts shall be published by the Society without the consent of the Directors. Any motion to print an address, or other paper read before the Society, or any other matter belonging to the Society, shall be referred to the Committee on Publication, who shall report to the Directors. The Committee on Publication may make suggestions to the Directors, from time to time, with reference to the publication of such papers as in their judgment should be published by the Society; and this Committee shall have the care, direction and supervision of the publication of all papers which the Directors may authorize to have published.

Members of the Society shall receive all the publications of the Society free of charge.

ARTICLE XII.

This Society may, by a vote of a majority of all its active and life members, become a branch of an American Astronomical Society, should one be formed.

ARTICLE XIII.

It shall be the duty of the Directors, in case any circumstances shall arise likely to endanger the harmony, welfare or good order of the Society, to call a special meeting of the Society; and if, at such meeting, after an examination of the charges, and hearing the accused, who shall have personal notice of such proceedings, it shall be proposed that the offending member or members shall be expelled, a vote by ballot shall be taken, and if two-thirds of the members present vote in favor thereof, the offending member or members shall be expelled.

ARTICLE XIV.

The Directors shall meet half an hour before the stated time of each bi-monthly meeting, and at such other times as they may appoint. The President, or, in his absence, any one of the Vice-Presidents may call special meetings of the Board of Directors at any time. Notice of the time and place of such meeting shall be given by the Secretaries, by depositing in the post-office at San Francisco a notice of the time and place, addressed to each Director personally, at his last known place of residence, with the postage thereon prepaid, six days before the time of meeting.

ARTICLE XV.

The By-Laws may be amended at any time by a consenting vote of nine members of the Board of Directors at any duly called meeting thereof.

ARTICLE XVI.

In order to increase the usefulness of the Society, any groups of its members residing in the same neighborhood (except in the City and County of San Francisco, State of California) are authorized to form local organizations which shall be known as "The ——— Section of the Astronomical Society of the Pacific."

No section shall be formed except by the consent of the Board of Directors of the parent Society.

The proceedings of such sections may be printed in the Publications of the Astronomical Society of the Pacific, either in full or in abstract, and the parent Society shall not be in any way responsible for publications made elsewhere.

No person not a member of this Society in good standing shall be eligible to membership in a section, nor shall membership in a section interfere in any way with the status of the person as a member of this Society.

The special expenses of each section shall be borne by the group of members composing it, and this Society shall not be liable for any debts incurred by any section.

NOTICE OF DR. DREYER'S BIOGRAPHY OF TYCHO BRAHE.

By Torvald Köhl.

The Director of the Armagh Observatory in Ireland, Dr. J. L. E. Dreyer, whose native country is Denmark, has not long ago written an excellent work under the title: Tycho Brahe, A Picture of Scientific Life and Work in the Sixteenth Century. 8vo. It has been published by the Editors Adam and Charles Black in Edinburgh and appears, as might be expected from that firm, in a very nice shape. The work is dedicated to Ralph Copeland, the distinguished Astronomer Royal for Scotland, a friend of the author, and consists of xvi + 405 pages.

The book is prettily illustrated by several woodcuts, representing: Hveen at the time of Tycho Brahe; Uraniborg and Grounds; Uraniborg from the East; Plan of the Ground Floor of Uraniborg; Stierneborg, seen from the West; Plan of Stierneborg; The Tychonic System of the World; Gemma's Astronomical Ring; Armillæ a Equatoriæ Maximæ; Sextans Trigonicus; Transversal Divisions. Besides the likeness of Tycho Brahe, found in England in 1876, the work contains some superb reproductions of photographs: Mural Quadrant; Castle of Benatky; Villa of Ferdinand I; Tomb of Tycho Brahe.

Dr. Dreyer is building on a deep study of the works of Tycho Brahe and knows to the least details all that has been written about the famous Danish astronomer. The book is brightly written and we confidently recommend it to the members of the Astronomical Society of the Pacific as being of great historical interest. With much ability the author guides the reader through the dark age in which the "reformer of observational astronomy" dwelt on our planet.

After having treated "The Revival of Astronomy in Europe" the author gives an interesting description of Tycho Brahe's youth. It is pretty well known how the heaven itself claimed the attention of the young TYCHO. "On the 21st of August, 1560, an eclipse of the sun took place, which was total in Portugal, and of which CLAVIUS has left us a graphic description. Though it was only a small eclipse at Copenhagen it attracted the special attention of TYCHO, who was then only 14 years old. When he saw the eclipse take place at the predicted time it struck him as something divine that men could know the motions of the stars so accurately that they could long before foretell their places and relative positions."

But the lively mind of the young student was soon drawn in other directions, and from the 30th day of December, 1570, till November, 1572, we do not possess a single astronomical observation made by TYCHO BRAHE, while during this time he worked with great energy at chemical experiments; and now a most unusual and startling celestial phenomenon was necessary to rouse him to renewed exertion and show him his real position in future as a diligent laborer in astronomy. This phenomenon was the appearance of the new star of 1572.

In a most attractive manner Dr. DREYER tells this important chapter of the great astronomer's life.

Perhaps any one may think that too much space in the following chapters has been devoted to the consideration of the astrological fancies of the Middle Ages; but doubtless the author is right when he in the Preface, with regard to this point, states: "If the study of the history of science is to teach us anything, we must make ourselves acquainted with the by-paths and blind alleys into which our forefathers strayed in their search for truth, as well as with the tracks by which they advanced science to the position in which our own time finds it."

The author attains his purpose which is to let the reader feel the same veneration for his hero as he feels himself, and he succeeds in distributing praise and blame in a moderate and wise manner. Of course the contest resulting in TYCHO BRAHE'S departure from his native land, to which he never returned, has been treated with much extension in the chapter on "The last years at Hveen, 1588–1597." From these earthly troubles it is encouraging to turn to the celestial works of that time. The improtance of TYCHO BRAHE'S scientific fights and victories has been inculcated in a drastic manner by the apparently so singular words, p. 175: "The Copernican System as set forth by

COPERNICUS, therefore, did not advance Astronomy in the least; it merely showed that it was impossible to calculate the motions of the planets without having the origin of the co-ordinates in the centre of the earth. But of proofs of the physical truth of his system, COPERNICUS had given none, and could give none; and, though there can hardly be any doubt that he himself believed in the reality of the earth's motion, it is extremely difficult to say of most of his so-called followers whether they had any faith in that motion or merely preferred it for geometrical reasons.

Though against his own wishes TYCHO BRAHE has contributed very much to the success of the Copernican system, for the numerous and most accurate observations made by the Danish astronomer on his little island in the Sound between Seeland and Scania are the source, from which JOHANNES KEPLER deduced his renowned laws. "ARCHIMEDES of old had said, 'Give me a place to stand on, and I will move the world?' TYCHO BRAHE had given KEPLER the place to stand on, and KEPLER did move the world!" On his death-bed the great observator several times exclaimed:

"Ne frustra vixisse videar!"

His death occurred on the 24th day of October, 1601. The future will bear witness that he did not live in vain.

As his countryman, I allow myself to congratulate the author, thanking him heartily for his excellent work.

ODDER, DENMARK, 1891, April 15.

THE PERIOD OF THE ROTATION OF THE SUN NEAR THE POLES, AS DERIVED FROM THE CORONAS OF 1878 AND 1889.

BY PROFESSOR FRANK H. BIGELOW.

In the *American Journal of Science* for November, 1890, the formulae for discussing coronas, and the results obtained by a study of the photographs taken during the eclipse of July 29, 1878, were presented and fully explained. In this paper the conclusions and the deductions to be derived from the coronas of Jan. 1, 1889, and Dec. 22, 1889, are added, with the period of the rotation of the Sun as found from these three coronas.

The following tables summarize the data in the briefest form.

Column 1 shows the number of rays which were measured on the photographs.

Columns 2 and 3 give the polar co-ordinates of each point of the ray, at least three points being measured, the first near the disk, the second at a mid point, and the third near the visible extremity of the ray. The axis of reference was taken by setting the thread on the projected ray whose trace had a radial direction from the centre of the disk.

The column α gives the angle between the plane of the ray and the plane of the disk, which is taken as the plane passing through the centre of the sun at right angles to the line of sight. Strictly, the planes of the coronal rays intersect in an axis which does not coincide with the plane of the disk, and a slight error is admitted by assuming provisionally that it does. It is one object of our investigation to discover the angular distance between the pole of the corona and its trace.

Now, $$\sec^2\alpha = \frac{X_2^{\frac{4}{3}} Y_1^2 - Y_2^2 X_1^{\frac{4}{3}}}{X_1^{\frac{4}{3}} X_2^2 - X_2^{\frac{4}{3}} X_1^2}$$

where $x_1 = r_1 \sin\theta_1$ $y_1 = r_1 \cos\theta_1$ for the first point,

and $x_2 = r_2 \sin\theta_2$ $y_2 = r_2 \cos\theta_2$ for the second point,

Using all values of $(r . \theta)$ we obtain three values of α. The adopted value is given in the table.

The column θ_0 gives the angle from the coronal pole at which each ray springs from the surface of the sun, in the direction α from the plane of the disk, the results being computed for each point of the ray. If the angle α is inaccurate the values of θ_0 will progress in one direction, and hence a check is obtained for the adopted α. At this step a second computation is frequently required. The outstanding irregularities arise from the difficulty of setting the measured points of the photograph on the true stream lines of the corona.

Then, $$\sin^2\theta_0 = \frac{x^2 \sec^2\alpha}{(x^2 \sec^2\alpha + y^2)^{\frac{3}{2}}}$$

where x and y have three values in order. The columns r', θ' give the co-ordinates in space of the point whose projected position we see on the photograph. We present only that corresponding to the first point of the ray; the others could be found by extending the computation.

Next,
$$r'^2 = x_1^2 \sec^2 \alpha + y_1^2$$
$$\sin^2 \theta' = r' \sin^2 \theta_0.$$

This will give the position of the extremities of the rays as seen from the center of the sun, by taking the co-ordinates (r_n, θ_n), and they may be used in considering the relations of these positions to the sun spots.

The column p gives the angle at the center of the sun from a point (r', θ') to the pole of the disk, that is to the trace of the true coronal pole, θ' being the angle to the coronal pole itself. If p is greater than θ', then the pole of the corona is on the earth side of the disk, since it is evident that the rays that are photographed are those which lie on the earthward side of the sun,

$$\tan p = \tan \theta_1 \sec \alpha.$$

Column c gives the angular distance of the coronal pole from its projection on the plane of the disk.

$$A = 90 - \alpha$$
$$\sin B = \sin p \cos \alpha \operatorname{cosec} \theta'$$
$$\tan \tfrac{1}{2} c = \frac{\cos \frac{1}{2}(A + B)}{\cos \frac{1}{2}(A - B)} \cdot \tan \tfrac{1}{2}(p + \theta').$$

Each quadrant is computed independently, and the mean of the two quadrants about each pole, North or South, will eliminate the error of selecting the position of the coronal pole, at the beginning of the measures.

To recapitulate, columns log r_n, θ_n, give the co-ordinates of the measured points, $n = 1 \cdot 2 \cdot 3 \ldots$, as projected; the columns α, θ_0, give the angular co-ordinates of the point on the sun's surface from which the ray springs; the columns log r', θ', the co-ordinates of the point in space, projected in the picture; the columns θ', p, c, the sides of the spherical triangle formed by point on the ray, the pole of the corona, and the trace on the plane of the disk.

By means of the resulting data an accurate model of the corona can be made.

Corona of July 29, 1878.—N. E. Quadrant.

Ray.	log r_n	θ_n	a	θ_0	log r′	θ′	p	c
		° ′	°	° ′		° ′	° ′	° ′
1	0.00000	3 40	89 0	.....	0.21388	39 20	40 55	1 35.0
	0.09225	0 52		30 40				
	0.17499	1 30		28 35				
2	0.00000	0 2	88 50	.....				
	0.10804	3 22		28 32				
	0.18808	6 30		.....				
3	0.00000	3 38	85	28 43	0.09159	34 45	36 4	1 20.2
	0.10959	7 6		32 55				
	0.16603	8 56		30 59				
4	0.00000	6 50	81	31 8	0.09717	36 3	37 27	1 24.5
	0.10959	13 21		33 39				
	0.17587	17 42		30 32				
5	0.00000	11 35	75	32 41	0.09678	37 19	38 23	1 5.3
	0.10284	16 27		33 17				
	0.17940	21 28		31 32				
6	0.00000	19 17	64	33 25	0.08194	38 41	38 36	−0 5.5
	0.12328	26 00		33 18				
	0.13800	30 31		34 34				
7	0.00000	28 31	49	36 0	0.05725	38 46	39 38	1 9.0
	0.11573	36 48		36 23				
	0.18419	41 18		35 16				
8	....	.....						
	0.09757	48 20	24	42 25	0.12036	49 48	50 53	2 46.3
	0.17543	56 9		42 23				
	0.25638	61 40		40 16				
				Mean...........................				1 9.4

July 29, 1878.—N. W. Quadrant.

Ray.	log r_n	θ_n	a	θ_0	log r′	θ′	p	c
1	0.00330	11 15	75	33 5	0.09564	35 15	37 33	2 24.0
	0.09757	12 0		30 17				
	0.16376	14 30		30 2				
2	0.00000	13 17	65	28 2	0.05720	29 20	29 11	−0 1.6
	0.10284	15 30		27 41				
	0.16694	16 44		26 11				
3	0.00000	15 20	73	36 30	0.12128	40 52	43 10	+2 24.5
	0.10284	19 1		34 5				
	0.18593	23 1		32 5				
4	0.00000	18 58	68	34 52	0.10837	38 49	42 32	+4 2.6
	0.11522	24 5		33 30				
	0.18549	29 24		32 26				
5	0.00000	22 42	59	34 24	0.07499	37 8	39 5	+2 17.0
	0.10804	30 14		35 0				
	0.19236	39 22		34 23				
	0.23837	43 26		33 5				
	0.28825	47 34		31 29				
6	0.10284	47 35	30	41 55	0.13909	51 9	51 39	+1 0.5
	0.21152	61 14		41 58				
	0.27012	69 28		40 49				
				Mean.............................				2 0.3

Corona of July 29, 1878.—S. W. Quadrant.

Ray.	log r_n	θ_n	a	θ_0	log r'	θ'	p	c
		° ′	°	° ′		° ′	° ′	° ′
1	0.00000	2 39	87	35 0	0.12501	38 35	41 29	2 51.3
	0.10388	2 56		31 41				
	0.16148	3 20		30 21				
2	9.99667	4 21	84	29 22	0.08771	34 9	36 3	1 58.1
	0.11062	6 51		31 23				
	0.17940	8 32		30 44				
3	0.01000	6 50	82	33 59	0.11735	37 51	40 44	2 56.6
	0.11062	8 37		32 26				
	0.17808	11 16		30 50				
4	0.00000	9 0	78	30 17	0.09399	34 36	37 18	2 45.3
	0.08848	11 37		31 25				
	0.16603	13 58		30 14				
5	0.00000	13 1	75	33 51	0.11606	40 10	41 46	1 12.3
	0.08685	20 43		35 51				
	0.14375	20 25		33 20				
6	0.00330	25 12	59	36 33	0.09166	41 6	42 25	1 8.9
	0.10804	33 37		36 35				
	0.16240	39 1		35 41				
7	0.09225	39 2	48	38 59	0.17873	50 45	50 28	−0 23.7
	0.15131	47 28		38 57				
8	0.11826	47 30	33	41 6	0.16308	52 11	52 27	0 30.6
	0.18808	55 58		41 7				
	0.23876	62 52		40 30				
				Mean	....			1 45.0

July 29, 1878.—S. E. Quadrant.

Ray.	log r_n	θ_n	a	θ_0	log r'	θ'	p	c
1	0.00000	0 49	88 50	31 41	0.08655	38 35	41 29	2 51.3
	0.09757	1 55		33 25				
	0.17053	2 20		29 28				
2	0.00066	1 7	88 40	30 28	0.08100	34 9	36 3	1 58.1
	0.08139	3 32		32 34				
	0.14755	7 40		.....				
3	0.00208	9 7	79	34 25	0.11272	37 51	40 44	2 56.6
	0.08249	14 40		34 59				
	0.15224	18 30		31 48				
4	0.00066	14 22	71	33 45	0.09148	34 36	37 18	2 45.5
	0.10804	20 48		34 1				
	0.19448	28 32		31 38				
5	0.00133	18 14	66	34 1	0.08849	40 10	41 46	1 12.3
	0.11573	25 51		34 19				
	0.17053	31 4		33 25				
6	0.00066	20 42	62	34 52	0.08014	41 6	42 25	1 8.9
	0.13800	31 32		34 54				
	0.21718	37 50		32 38				
7	0.00199	31 14	42	35 8	0.04482	50 45	50 28	−0 23.7
	0.11826	37 57		35 13				
	0.19150	43 28		35 11				
8	9.00723	34 38	40	39 7	0.05173	52 11	52 27	0 30.6
	0.11927	43 34		39 11				
	0.19065	50 17		38 39				
	0.25120	57 26		37 26				
				Mean	....			1 45.0

Corona of January 1, 1889.—N. E. Quadrant.

Ray.	log r_n	θ_n	a	θ_o	log r′	θ′	p	c
		° ′	° ′	° ′		° ′	° ′	° ′
1	0.08104	1 43	88 30	37 36	0 18274	44 55	48 52	3 56.9
	0.09463	2 0		33 46				
	0.18056	2 53		33 20				
2	0.00362	2 50	85	27 19	0.06379	30 51	29 35	−1 14.9
	0.12208	4 20		29 44				
	0.20126	5 3		28 18				
3	0.00207	5 51	78	24 45	0.04701	26 7	26 14	0 46.6
	0.09919	6 47		24 28				
	0.18566	8 23		24 45				
4	0 20618	11 16	55	18 38	0.02246	18 31	19 9	0
	0.11815	12 27		17 51				
	0.18499	13 24		17 35				
5	0.00460	16 35	64	31 17	0.06709	34 3	34 11	0
	0.10084	19 53		30 53				
	0.18397	22 31		31 29				
6	0.00618	29 17	52	38 0	0.07799	42 7	42 20	0 1.5
	0.08960	36 56		38 25				
	0.16098	43 12		37 3				
7	0.00618	42 3	25	43 11	0.02639	44 31	44 44	0 30.8
	0.10411	49 45		43 5				
	0.17228	55 33		42 17				
				Mean	....	....	....	0 34.4

January 1, 1889.—N. W. Quadrant.

1	0.00207	2 40	86	30 22	0.08166	33 56	33 44	0 19.3
	0.07763	3 28		31 28				
	0.17158	4 19		29 49				
2	0.00259	5 50	81	30 1	0.07748	32 36	33 9	0 32.8
	0.10817	7 54		30 34				
	0.17088	8 40		27 59				
3	0.00104	6 32	81	32 7	0.09140	36 10	36 12	4 40.4
	0.08960	9 15		33 1				
	0.16490	11 25		31 7				
4	0.00618	9 24	77	32 7	0.09430	36 33	36 20	−0 13.2
	0.10736	15 48		33 48				
	0.18397	18 48		31 0				
5	0.00464	13 17	72	33 7	0.16095	41 14	37 22	−4 3.1
	0.09588	20 0		34 31				
	0.17988	25 8		31 57				
6	0.09170	27 10	58	34 14	0.17982	41 43	44 5	2 49.7
	0.17018	36 17		34 36				
	0.22351	43 10		33 33				
	0.28895	48 14		31 17				
	0.32400	50 59		30 4				
				Mean	....	....	....	0 34.6

Corona of January 1, 1889.—S. W. Quadrant.

Ray.	log r_n	θ_n	a	θ_o	log r′	θ′	p	c
		° ′	° ′	° ′		° ′	° ′	° ′
1	0.99845	2 19	86 50	32 8	0.06585	34 41	31 11	−3 29.1
	0.07676	3 3		32 39				
	0.17018	4 12		30 42				
2	9.99897	5 27	82	31 1	0.08066	33 4	34 26	0 12.2
	0.10411	6 10		29 0				
	0.17018	7 57		29 27				
3	0.00104	6 59	80	31 29	0.08551	35 16	35 12	0
	0.10248	9 57		32 16				
	0.15775	11 6		30 53				
4	9.99845	11 26	72	30 27	0.06716	32 54	33 12	0 18.9
	0.10615	14 50		30 41				
	0.17367	16 25		29 25				
5	9.99897	14 9	72	34 27	0.09638	39 5	39 13	0 7.9
	0.05767	17 51		35 10				
	0.12984	21 17		33 26				
6	0.00104	22 23	46	29 25	0.03243	30 34	30 40	0 8.5
	0.10817	26 38		29 29				
	0.17816	29 33		29 5				
7	0.00104	28 21	53	37 49	0.07365	40 36	41 53	1 37.8
	0.07676	34 42		35 53				
	0.15739	40 41		36 28				
8	9.99479	39 13	36	42 55	0.03261	44 46	45 15	0 50.5
	0.07676	46 41		43 11				
	0.17954	55 25		42 2				
			Mean..............................					−0 1.7

January 1, 1889.—S. E. Quadrant.

1	0.00104	1 12	88 20	31 44	0.09168	35 55	35 46
	0.08195	1 40		32 40			
	0.15231	2 4		31 11			
2	9.99845	3 44	83 30	27 47	0.05970	29 31	29 58
	8.10614	4 26		27 4			
	0.17713	5 23		27 17			
3	9.99845	6 23	80	29 56	0.07117	32 52	32 48
	0.09795	8 13		30 14			
	0.16312	9 57		29 51			
4	9.99845	10 3	76	32 24	0.08502	36 4	36 14
	0.10001	14 29		33 8			
	0.17644	18 15		31 17			
5	9.99949	15 15	69	33 23	0.08308	37 50	37 16
	0.08960	20 18		33 55			
	0.16737	26 40		32 46			
6	0.05994	23 26	61	33 24	0.15011	41 24	40 29
	0.12675	29 37		34 50			
	0.20709	37 45		33 10			
7	0.04055	21 2	65	34 53	0.14927	42 11	43 24
	0.12522	31 15		35 31			
	0.20061	40 57		32 55			
8	0.05767	31 37	58	37 49	0.17342	47 11	49 17
	0.12598	39 57		37 17			
	0.20061	47 4		35 30			
			Mean......................				0 34.6

Corona of December 22, 1889.—N. E. Quadrant.

Ray.	log r_n	θ_n	a	θ_o	log r'	θ'	p	c
		° ′	° ′	° ′		° ′	° ′	° ′
1	0.00000	1 58	87 30	33 16	0.10477	34 49	38 13	3 15.8
	0.08579	2 5		30 22				
	0.16769	2 3		27 35				
2	0.03820	4 5	82 30	25 31	0.09392	28 43	28 40	0 8.4
	0.11484	4 46		25 42				
	0.16769	5 11		25 27				
3	0.03668	7 52	79	30 33	0.12379	35 53	35 55	3 47.5
	0.08905	9 23		31 9				
	0.14921	10 22		29 57				
4	0.05612	13 2	68	27 25	0.11502	31 28	31 43	0 16.4
	0.10580	14 25		27 32				
	0.16085	15 20		26 41				
5	0.05465	13 20	71	30 15	0.13512	36 3	36 3	0 0
	0.09337	14 32		30 12				
	0.14087	16 39		30 17				
6	0.04336	15 57	68	31 38	0.12592	35 39	37 20	1 48.4
	0.09471	18 8		31 42				
	0.14207	20 6		31 9				
7	0.04124	17 27	65	31 28	0.11640	36 28	36 28	0 0
	0.08579	19 30		31 39				
	0.14565	21 56		31 1				
8	0.04606	42 36	48	28 43	0.08240	31 53	31 53	0 0
	0.10711	24 51		28 37				
	0.14684	26 52		28 48				
9	0.04666	25 42	60	35 59	0.14380	43 48	43 54	0 3.9
	0.09122	29 25		36 0				
	0.13724	34 40		35 47				
10	0.04815	31 56	54	38 7	0.14050	46 23	46 41	0 21.5
	0.11228	39 39		38 24				
	0.16428	46 28		37 31				
			Mean	....				0 58.2

Corona of December 22, 1889.—N. W. Quadrant.

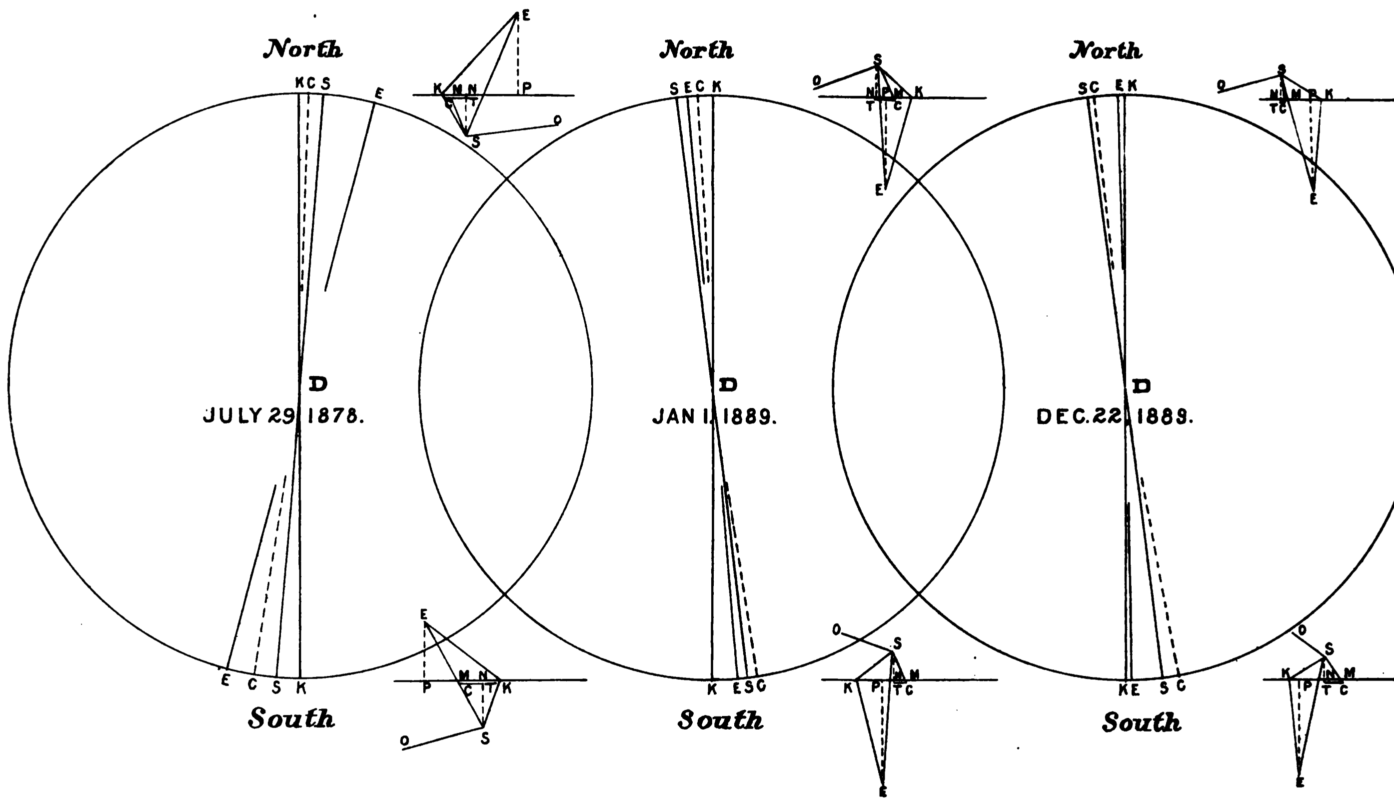
Ray.	log r_n	θ_n	a	θ_o	log r'	θ'	p	c
		° ′	° ′	° ′		° ′	° ′	° ′
1	0.02740	3 7	85	28 33	0.09832	32 42	32 0	−0 36.7
	0.08001	3 46		29 27				
	0.13724	4 7		28 33				
2	0.04185	5 20	80	25 7	0.09510	28 21	28 16	−0 6.2
	0.09256	5 47		24 58				
	0.13797	6 31		25 28				
3	0.04275	8 39	76 50	29 0	0.11787	33 44	33 8	−0 3.8
	0.08029	9 23		29 0				
	0.13966	10 53		28 59				
4	0.04215	14 7	63	26 0	0.08695	29 0	28 59	0 8.5
	0.09391	15 23		25 59				
	0.14014	16 48		26 4				
5	0 04426	18 59	67	34 1	0.14458	41 15	41 22	0 6.8
	0.08589	22 0		34 22				
	0.13408	24 33		33 24				
6	0.05318	22 39	62	34 13	0.14475	41 31	41 38	0 7.6
	0.09658	26 4		34 32				
	0.15507	30 6		33 40				
7	0.04426	27 55	50	34 23	0.10312	39 23	39 30	0 0
	0.08987	30 49		34 31				
	0.14494	34 4		34 1				
8	0.04576	37 23	36	38 22	0.08437	43 4	43 22	0 30.1
	0.11330	42 45		38 43				
	0.18324	47 27		37 37				
9	0.05612	42 44	8	39 39	0.05809	42 36	43 1	4 7.5
	0.13064	47 47		39 40				
	0.20495	51 34		38 33				
				Mean..............................				0 28.5

Corona of December 22, 1889.—S. W. Quadrant.

Ray.	log r_n	θ_n	α	θ_o	log r'	θ'	p	c
		° ′	° ′	° ′		° ′	° ′	° ′
1	0.03052	2 19	86 50	30 50	0.12340	36 43	36 13	−0 26.9
	0.06766	2 52		32 21				
	0.14207	3 15		30 33				
2	0.05612	5 52	81	28 9	0.13173	32 17	33 18	1 16.7
	0.10712	6 10		27 12				
	0.14327	6 26		26 37				
3	0.03361	8 20	76 30	28 14	0.09965	32 3	32 6	0 2.7
	0.07751	9 5		28 11				
	0.14850	10 48		28 18				
4	0.03973	13 48	65	26 56	0.09021	30 13	30 10	−0 2.8
	0.09711	15 33		27 15				
	0.14803	16 42		26 46				
5	0.06394	20 12	58	28 58	0.12280	34 9	34 46	0 42.7
	0.10266	21 50		29 2				
	0.14921	23 42		29 31				
6	0.05318	25 8	58	34 33	0.13566	41 21	41 31	0 11.6
	0.10056	28 52		34 50				
	0.16314	32 56		33 52				
7	0.07751	31 47	54	36 40	0.16922	46 27	46 27	0 0
	0.12668	38 2		36 38				
	0.18802	44 13		36 34				
8	0.06623	32 23	54	37 34	0.16047	46 44	47 11	0 34.5
	0.10711	37 32		37 55				
	0.16085	45 27		37 25				
	0.20661	51 25		36 5				
			Mean................................					0 1.8

December 22, 1889.—S. E. Quadrant.

Ray.	log r_n	θ_n	α	θ_o	log r'	θ'	p	c
1	0.03515	3 6	86	31 35	0.13695	37 43	37 50	0 11.1
	0.09658	4 11		31 30				
	0.14992	5 7		31 26				
2	0.07050	3 34	86	32 4	0.19716	41 35	41 47	0 12.7
	0.09604	5 2		33 39				
	0.15716	8 13		30 4				
3	0.03576	7 13	82	31 46	0.18696	40 39	38 3	−2 37.6
	0.09938	7 37		31 53				
	0.14087	8 54		31 24				
4	0.05465	10 3	77	31 16	0.15278	38 11	38 14	0 3.5
	0.11099	11 55		31 19				
	0.14850	13 35		31 6				
5	0.03973	11 59	75	32 35	0.14215	38 55	39 21	0 28.2
	0.10970	15 28		32 48				
	0.17996	19 46		31 19				
6	0.05465	15 9	72	33 4	0.16300	40 11	41 14	1 6.1
	0.11099	19 16		33 31				
	0.16995	23 35		32 12				
	0.21683	27 23		30 33				
7	0.09256	22 53	62	33 56	0.18559	42 55	41 57	−1 0.9
	0.13773	26 38		33 41				
	0.18759	29 40		32 29				
			Mean................................					−0 13.8



THE RELATIVE POSITIONS OF THE POLES OF THE ECLIPTIC, CELESTIAL EQUATOR, SUN'S AXIS, AND AXIS OF THE CORONA, FOR THE ECLIPSES OF JULY 29.1878. JAN.1,1889. DEC.22,1889.

I should like to direct attention to the comparative smoothness of the results for the Corona of Dec. 22, 1889, as showing what can be done by this analysis. The improvement arises from the good size of the photograph, and the practice in measuring up such plates, as well as from increased judgment in the application of the formulæ. In some parts there is little to be desired, unless, perchance, an attempt be made to carry the problem further in its physical aspects.

If I is the inclination of the Sun's Equator to the Ecliptic, $7^\circ\ 15'$,

w, the inclination of the Earth's Equator to the Ecliptic, about $23^\circ\ 27'.3$.

N, the longitude of the Node of the Sun's Equator, 74°.

$\odot$, the longitude of the Sun at the Epoch of the Eclipse,

D, the center of the Sun's disk, and the direction for position angles positive towards the West, we have,

$$H = SDK;\ \tan H = \tan I \cos (\odot - N),$$
$$G = EDK;\ \tan G = \tan w \cos \odot.$$

If the projection of		E is P,
"	"	S is N,
"	"	C is M,
"	"	K is K,

we have the following formulæ:

$$PM = PN + NM, \qquad CT = MN \cdot \cos CM,$$
$$NKS = \odot - N, \qquad \cos CS = \cos CT \cos ST,$$
$$\tan NK = \cos NKS \tan KS, \qquad \cos CST = \sin ST \cos CT,$$
$$\sin SN = \sin NKS \sin KS, \qquad \cos NSK = \sin NKS \cos NK,$$
$$ST = SN + MC, \qquad CSK = NSK - CST,$$

$KOS = 90^\circ$; O, the direction of the Node N.

$OSC = OSK - CSK$, the longitude of the Coronal Pole, on the plane of the Sun's Equator from the Node.

$90 - CS$, the latitude of the Coronal Pole from the Sun's Equator.

	July 29, 1878.		Jan. 1, 1889.		Dec. 22, 1889.	
	N.	S.	N.	S.	N.	S.
	° ′	° ′	° ′	° ′	° ′	° ′
I (K S).....	7 15	7 15	7 15	7 15	7 15	7 15
ω (K E)....	23 27.4		23 27.2		23 27.2	
N..........	74		74		74	
☉..........	126 10.9		281 20.6		270 54.2	
H (K D S)..	+ 4 27.6	− 4 27.6	− 6 26.8	+ 6 26.8	− 6 56.4	+ 6 56.4
G (E D K)..	− 14 22.1	+ 14 22.1	+ 4 52.6	− 4 52.6	+ 0 23.5	− 0 23.5
G+H (E D S)	− 9 54.5	+ 9 54.5	− 1 34.2	+ 1 34.2	− 6 32.9	+ 6 32.9
N M.......	− 2 30	− 4 30	+ 4 0	+ 2 0	+ 1 0	+ 3 30
M C.......	+ 1 35	+ 1 28	+ 0 35	+ 0 17	+ 0 43	+ 0 2
P M........	− 12 24.5	+ 5 24.5	+ 2 25.8	+ 3 34.2	− 5 32.9	+ 10 2.9
N K.......	4 27.6	4 27.6	6 26.8	6 26.8	6 56.4	6 56.4
S N........	5 41.6	5 41.6	3 19.4	3 19.4	2 6.2	2 6.2
C S........	4 48	6 11	5 35	3 38	3 0	3 58
C S T......	31 21	46 53	45 45	33 22	19 32	61 55
N S K......	38 3	38 3	62 9	62 9	73 13	73 13
K S C......	6 42	84 56	16 24	95 31	53 41	135 8
K S O......	90	270	90	270	90	270
O S C......	83 18	185 4	73 36	174 26	36 19	134 52
90 − C S....	85 12	83 49	84 25	86 22	87 0	86 2

Difference in Longitude of the North and the South Poles.

Corona of July 29, 1878.......	101° 46′
" Jan. 1, 1889.......	100 53
" Dec. 22, 1889.......	98 33
Mean............	100° 24′

Mean Latitude of the North Pole.........85° 32′
" " " South Pole.........85° 24′

In all the coronas here presented the pole is on the earthward side of the plane of reference. Special attention should be called to Column θ_0 as it demonstrates the fact, without an exception, that the coronal rays spring from the Sun in a narrow belt, whose middle is about 34° from the coronal pole, the width being 10° to 15° in latitude. This phenomenon is such as to indicate that the terrestrial aurora had a similar historical origin, when the Earth was in a heated condition.

Having thus obtained one co-ordinate for the pole of the corona, namely c, we get the second by the angle between the trace of this pole and the trace of the sun's axis of rotation on same plane. Theoretically this should be very simple, and it would be so if the photograph were accurately oriented, but there is much to be desired in this respect, and it is hoped that the observers of coming eclipses will recognize its importance. I think that the most important inaccuracies of this work come in at this step, but I do not see how to remedy it at this time.

Diagrams are given showing the position angles of the poles of the Ecliptic, K, the Celestial Equator, E, the Sun's axis of rotation, S, and the Coronal pole, C, and side drawings of these points as existing on the surface of the sphere for each of the three Eclipses.

I have made two changes in the computation of July 29, 1878, the first in the value of M N by orienting the sun's axis relatively to the coronal axis $1^\circ\ 30'$ W. from N.; and the second in applying the value of M C with the opposite sign at the south pole as I had made a mistake in this respect.

The agreement of the difference of longitude, $100^\circ\ 24'$, shows that the poles rotate with the body of the Sun, in other words that the Corona itself rotates with the Sun, and must therefore be regarded as a fixed attachment to it. While the polar distance agrees for the two poles, they are twisted about in longitude so that the south pole precedes the north pole by about 100°, again reminding us of the condition of the earth so far as the location of the magnetic poles are concerned, in the latter case the difference of longitude being about 115°.

Compute the distance in a great circle between the north and south pole of the corona at the three eclipses from the respective latitudes and longitudes, with the view of strengthening the argument that the poles of the corona rotate with the body of the sun.

	(1)	(2)	(3)
a = North Polar distances (N)	$4^\circ\ 48'$	$5^\circ\ 35'$	$3^\circ\ 0'$
b = " " " (S)	173 49	176 22	176 2
C = Difference in Longitude	101 46	100 53	98 33

$$k \sin K = \sin a \cos C$$
$$k \cos K = \cos a$$
$$\cos c = k \cos (b - K)$$

c = Great Circle distance	$172^\circ\ 59'$	$173^\circ\ 56'$	$175^\circ\ 23'$
Mean	174 06'		

The result may be taken as testimony that the poles are fixed.

The length of the chord joining the north and south poles of the corona is

$$d = 2r \sin \tfrac{1}{2}c$$
$$= 1.99619\ r$$

If the radius of the sun r is taken as 866,500 miles, the axis of polarization in the body of the sun, to which the internal lines of force are parallel is 1,729,700 miles in length.

To find the Period of the Rotation of the Sun at the Coronal Poles, in Latitude 85°.5.

Eclipse 1, 1878, July 29, $9^h\ 23^m$ G. M. T. = 1878 · $210^d.39097$
" 2, 1889, Jan. 1, 9 16 " = 1889 · 1 .38611
" 3, 1889, Dec. 22, 0 15 " = 1889 · 356 .03681

Eclipse intervals in Mean	(1) to (2)	(1) to (3)	(2) to (3)
Solar days	3808.8144	4163.4651	354.6507
Assumed Number of Revolutions	Revolutions. 138	Revolutions. 151	Revolutions. 12
	+349°.85	+311°.40	+312°.55
	50029°.85	54671°.40	4641°.55
Mean Daily Motion	13°.1353	13°.1312	13°.0876

These data should be given equal weights for the three eclipses, as the conditions are practically the same in each. Adopting equations of the form:

$$\theta\ (t_1 - t) = a$$
$$\theta\ (t_2 - t) = a + a_1$$
$$\theta\ (t_3 - t) = a + a_2$$

in which t is the epoch 1878.0, t_1, t_2 and t_3, the epochs of the three eclipses respectively, a the sidereal change in longtitude from t to t_1, and θ the mean daily motion in longitude, a and θ being the unknown quantities: The equations of condition are,

$$210.3910\ \theta - a = 0$$
$$4019.2054\ \theta - a - 50029.85 = 0$$
$$4373.8561\ \theta - a - 54671.40 = 0$$

The normal equations are,

$$35328877.\ \theta - 8603.46\ a - 440205067,$$
$$-\ 8603.5\ \theta + 3.\ a = 104701$$

and the solution is,

$$\theta = 13^\circ.13307 = 13^\circ\ 7'\ 59''$$
$$a = 2763^\circ.0$$

The equivalent Sidereal period is $27^d.41171 = 27^d\ 9^h\ 52^m\ 52^s$.
" " Synodic " $29.63580 = 29\ 15\ 15\ 33$.

If we compute the longitude of the coronal poles for 1878.0 as an epoch, we find from the three eclipses,

1878, July 29	200.3	302.1
1889, Jan. 1	209.1	310.0
1889, Dec. 22	198.1	292.7
Mean	201.2	301.6
Difference	104°.4	

These data, namely,

Longitude of North Coronal Pole for 1878.0 referred to the ascending node of the sun's equator on the plane of the ecliptic	201°.2
Sidereal period of the sun's rotation at the coronal pole	$27^d.41171$
or mean daily motion in longitude	13°.13307

furnish us with elements for predicting the position of the poles, and in consequence that of the corona at any epoch.

We are therefore in possession of such data as will enable us to make predictions as to the position of the poles of the corona at any epoch, and in consequence the relative form of the corona at the time as seen from the earth. A close comparison of a model with several photographs of recent eclipses displays a gratifying agreement in the details, and we hope to carry our study further in this direction.

The model also serves to strengthen the conviction that the sun-spots are probably formed by the descent of material from the extremities of the coronal streamers, in a vertical direction upon the sun. The circulation of the solar currents would therefore be, outwards along the coronal curves, under the law of repulsion inversely as the square of the distance, at the extremities of which a change in the physical condition takes place, by cooling or otherwise; then a return to the sun by the law of gravitation, the attraction being inversely as the square of the distance; and finally a slow drift of the solar surface towards the poles as already known to exist. This alternation of condition, by which the same matter is now repulsive and again attractive, seems to be a plausible explanation not only of this phenomenon but also of some other facts of solar physics.

The corona of Dec. 22, 1889, brings out an important circumstance. The originating belt seems to be somewhat nearer the poles than in the other coronas. If this shows that the belt moves up and down on the sun through a few degrees, we should remember that the extremities of the streamers, in consequence of the peculiar formation of the curves, will rise and fall to a greater extent, and the resultant parallels of the sun-spots will be modified in a similar manner. This accounts so well for the observed periodic changes in latitude for the spots, that it will be proper to investigate the question as far as possible.

The location of the coronal poles on one quadrant of the sun's surface will be the means of intensifying the forces that emanate from it on one side, and hence some color is given to those studies of terrestrial phenomena that point to the existence of a 27-day period, in response to the sun's rotation.

This analysis of the problem excludes all theories that ascribe the origin of the corona to extra-solar influences. We are not, however, in a position to say that the sun is magnetic because the coronal lines are similar to those surrounding a spherical magnet; nor that it is electrical, for the same reason. These phenomena are simply manifestations of the operations of the inverse of NEWTON'S Law, namely: repulsion in place of attraction. When matter attracts there is a center of attraction and of figure; when it repels, there are formed two poles of repulsion, and the body is polarized along an axis. If a name must be given to this theory of the corona, it will be more satisfactory to regard it as the *polarization theory of the solar corona.*

(SIXTH) AWARD OF THE DONOHOE COMET MEDAL.

The Comet Medal of the Astronomical Society of the Pacific has been awarded to E. E. BARNARD, Astronomer of the Lick Observatory, for his discovery of a Comet at 16 hours G. M. T., March 29, 1891. This is the fifteenth comet discovered by Mr. BARNARD.

The Committee on the Comet Medal,

EDWARD S. HOLDEN,
J. M. SCHAEBERLE,
CHARLES BURCKHALTER.

VISIBILITY OF INTERFERENCE-FRINGES IN THE FOCUS OF A TELESCOPE.*

BY ALBERT A. MICHELSON.

When the angle subtended by an object viewed through a telescope is less than that subtended by a light-wave at a distance equal to the diameter of the objective, the form of the object can no longer be inferred from that of the image. Thus, if the object be a disk, a triangle, a point, or a double star, the appearance in the telescope is nearly the same.

If, however. the objective is limited by a rectangular slit, or, better, by two such, equal and parallel, then, as has been shown in a former paper,† the visibility of the interference-fringes is, in general, a periodic function of the ratio of α, the angular magnitude of the source in the direction perpendicular to the length of the slits, and α_0, the "limit of resolution." The period of this function, and thence $\frac{\alpha}{\alpha_0}$, may be found with great accuracy; so that by annulling the greater portion of the objective the accuracy of measurement of the angular magnitude of a small or distant source may be increased from ten to fifty times. As ordinarily understood, this increase of "accuracy" would be at the cost of "definition" (which, in this sense, is practically zero); but if by "definition" we mean, not the closeness of the resemblance of the image to the object, but the accurracy with which the form may be inferred, then definition and accuracy are increased in about the same proportion.

In almost every case likely to arise in practice, the form of the source is a circular disk; and if the illumination over its surface were uniform, the only problem to be solved would be the measurement of its diameter. But in many cases the distribution is anything but uniform. If the curve representing the distribution along the radius be $i = \psi(r)$, then the element of intensity of a strip $y_1 dx$ will be

$$\int_{-y_1}^{y_1} \psi(r)\, dy = \phi(x),$$

* Reprinted, by request, from the *Philosophical Magazine*.

† "On the Application of Interference Methods to Astronomical Measurements" (Phil. Mag., July, 1890).

and it has been shown that the visibility-curve in this case is

$$V = \frac{\int \phi(x) \cos kx}{\int \phi(x)\, dx}.$$

This may be proved as follows:

The intensity of the diffraction-figure of a luminous point in a telescope with a symmetrical aperture is*

$$I^2 = \left[\int\int \cos \kappa\mu_1 x_1 \cos \kappa\nu_1 y_1 dx_1 dy_1\right]^2, \quad . \quad . \quad . \quad . \quad . \quad (1)$$

in which $k = 2\pi/\lambda$, μ_1 and v_1 are the angular distances from the center of the image, and x_1 and y_1 are the co-ordinates of the element of surface of the aperture.

If μ and ν are counted from the axis of the telescope and x, y, r are the co-ordinates of the luminous point, the expression becomes

$$I^2 = \left[\int\int \cos \kappa\left(\mu - \frac{x}{r}\right)x_1 \cos \kappa\left(\nu - \frac{y}{r}\right)y_1 dx_1 dy_1\right]^2. \quad . \quad (2)$$

If now the source is a luminous surface whose elements vibrate independently,

$$\bar{I} = \int\int I^2 dx\, dy. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

For the case of two equal apertures† whose centers are at $x_1 = -\frac{1}{2}a_{11}$ and $x_1 = +\frac{1}{2}a_{11}$,

$$I_{11}^2 = I^2 \cos^2 \tfrac{1}{2}\kappa a_{11}\left(\mu - \frac{x}{r}\right). \quad . \quad . \quad . \quad . \quad . \quad (4)$$

This substituted in (3) gives

$$\bar{I} = \int\int I^2 \cos^2 \tfrac{1}{2}\kappa a_{11}\left(\mu - \frac{x}{r}\right) dx\, dy.$$

Putting $\kappa a_{11}\mu = \theta$, $\kappa a_{11}/r = k_{11}$, and expanding,

$$2\bar{I} = \int\int I^2 dx\, dy + \cos\theta \int\int I^2 \cos k_{11}x\, dx\, dy$$
$$+ \sin\theta \int\int I^2 \sin k_{11}x\, dx\, dy. \quad . \quad . \quad . \quad . \quad (5)$$

Let $y = \phi(x)$ be the equation of the curve bounding the luminous surface; or, better, let $\phi(x)dx$ be the "total intensity" of a strip of width dx.

Denoting $\int_{-\phi(x)}^{+\phi(x)} I^2 dy$ by $F(x)$, and omitting the factor 2,

---

* "Wave Theory of Light," Rayleigh.

† More generally, for m equal equidistant apertures whose total area is constant,

$$I_m = I \frac{\sin \frac{1}{2} m\kappa\mu a}{m \sin \frac{1}{2}\kappa\mu a}.$$

equation (5) becomes

$$\bar{I} = \int F(x)dx + \cos\theta \int F(x)\cos kx\, dx + \sin\theta \int F(x)\sin kx\, dx,$$

or

$$\bar{I} = P + C\cos\theta + S\sin\theta. \quad \ldots \ldots \quad (6)$$

If the width of the apertures is small, compared with their distance, the variations of $F(x)$ with μ (or θ) may be neglected, and in this case the maxima or minima occur when

$$\tan\theta = \frac{S}{C}, \text{ or when } \bar{I} = P \pm \sqrt{C^2 + S^2}.$$

If now the visibility of the interference-fringes be defined as the ratio of the difference between a maximum and an adjacent minimum to their sum

$$V^2 = \frac{C^2 + S^2}{P^2},$$

or

$$V^2 = \frac{[\int F(x)\cos kx\, dx]^2 + [\int F(x)\sin kx\, dx]^2}{[\int F(x)\, dx]^2}. \quad \ldots \quad (7)$$

For narrow rectangular apertures,

$$F(x) = \int_{w_1}^{w_2} \frac{\sin^2 w}{w} dw.$$

In this expression, if $\nu = 0$ and b = length of aperture,

$$w_1 = \frac{\kappa b}{2r}\phi_1(x) \text{ and } w_2 = \frac{\kappa b}{2r}\phi_2(x).$$

So long as

$$\frac{2\phi(x)}{r} < \frac{\lambda}{b},$$

$F(x)$ is nearly proportional to $\phi(x)$; that is, so long as the angle subtended by the source is less than the limit of resolution of a telescope with aperture b, the brightness is proportional to the size of the object. For larger angles the proportionality may still be made to hold by a slight alteration in the focal adjustment; and to this degree of approximation we have

$$V_2 = \frac{[\int \phi(x)\cos kx\, dx]^2 + [\int \phi(x)\sin kx\, dx]^2}{[\int \phi(x)\, dx]^2}. \quad \ldots \quad (8)$$

If the source is symmetrical the second term vanishes, and the expression reduces to the original form.

It is possible that, in addition to the uses already mentioned, the "visibility-curve" may have an important application in the case of small spherical nebulæ. For from the form of this curve the distribution of luminous intensity in the globular mass may be inferred, which would furnish a valuable clue to the distribution of temperature and density in gaseous nebulæ.

When the source is so small as to be indistinguishable from a star, it would seem that this method is the only one capable of giving reliable information; but even in the case of bodies of larger apparent size it is equally applicable, may be made to give results at least as accurate as could be obtained by photometric measurements, and is far more readily applied.

REPORT MADE TO THE DIRECTOR OF THE ASTRONOMICAL OBSERVATORY OF TACUBAYA, IN REGARD TO OBSERVATIONS OF THE ZODIACAL LIGHT.*

The total eclipse of the Sun that took place on the 22d of December, 1889, presented exceptionally good conditions to study the Zodiacal light and crepuscular phenomena, on account of the fact that the zone of totality and its extension crossed our planet in the intertropical regions, where such phenomena take place with greater intensity and under better conditions for their observation; besides, the eclipse occurred at the time when the Zodiacal light shows its greatest extension and brightness. The eclipse began at sunrise for the occidental coast of America, and at sunset for the western coast of Africa. Therefore, the shadow of the Moon touched the Earth at the time when the Zodiacal light is seen distinctly, so that a rare opportunity was offered to the observers, to ascertain with certainty, whether or not the Zodiacal light is produced (at least in part) between the Earth and the Moon, or at a greater distance than that between our planet and its satellite. In order to observe the above-mentioned phenomena Sres. D. CAMILO A. GONZALEZ and D. FELIPE VALLE, of the Astronomical Observatory of Tacubaya, went to Progreso, Yucatan, Mexico.

The observations of the Zodiacal light extended from the 14th to the 25th of December, *i. e.*, seven days before and three days after the day of the eclipse, which took place on the 22d.

---

* Translated from the *Boletin del Observatorio Astronomico Nacional de Tacubaya*, by E. J. MOLERA.

There was no difference of any importance in the aspect of the Zodiacal light during the days preceding or following the day of the eclipse, but, "on the 22d, at 5^h 8^m 19^s A. M., common time at Progreso (the latitude of which is 21° 17′ 14″.3 N., and its longitude, from the Astronomical Observatory at Tacubaya, 38° 08′ E., or 5^h 58^m $38^s.2$ W. of Greenwich), at the moment we were watching with great attention the Zodiacal light, *we saw something like a veil or shadow spread itself over it, and diminish its intensity about one-half.* The phenomenon was noticed by the two observers *independently*, and the impressions that the phenomena made on both, *were identical.* It was due, without doubt, to the cone of shadow of the Moon projected on the matter that reflects the solar light directly, after it is reflected by our own planet. Accordingly, the phenomena took place several minutes before the totality of the eclipse began, as it should do, the matter that reflects the light, and produces the phenomenon being at a distance of many thousands of kilometers from the center of the Earth; the shadow, though lasting only a few moments, was gradual, and moved from the zenith to the horizon, or from west to east, in the exact direction that the march of the intersection of the cone of shadow of the Moon with the Earth followed. The notes of observation were:

December 22d, 1889, 3^h 55^m A. M.—The Zodiacal light is distinctly visible between α and β *Libræ* and δ and μ *Leonis*, and possibly as far as θ *Leonis*.

4^h 49^m.—It is seen more brilliantly in some places in the region that it occupies, for instance, near ζ *Libræ*, and it is considerable more brilliant than at the horizon.

5^h 08^m 19^s.—*The shadow of the Moon is projected over the Zodiacal light*, reducing the intensity of its brilliancy one-half.

5^h 15^m.—The most brilliant part of the Zodiacal light is at the extreme occidental side of *Scorpio*.

NOTE ON DARK TRANSITS OF *JUPITER'S* SATELLITES.

By John Tebbutt, F. R. A. S.

I have read with much interest the notices which have appeared in Nos. 10 and 11 of the *Publications* A. S. P. with reference to black transits of *Jupiter's* satellites. I have myself on various occasions observed dark transits both of the third and of the fourth satellite. (See *R. A. S. Monthly Notices*, vols. xxxiv and xxxviii, page 73, and *Ast. Nachrichten*, Band xlv, page 121). The first of these communications called forth interesting papers from Professor ALEXANDER and Doctor KLEIN. My own experience may be summed up as follows:—The satellite for some minutes after internal contact at ingress is seen as a bright spot. Its brightness gradually diminishes until the satellite becomes quite undistinguishable from the disc of the primary. The satellite remains invisible for some time, but long before its nearest approach to the center of the disc it becomes distinguishable as a faint dark spot. The dark phase gradually increases in intensity till the time of nearest approach and the phenomena for the rest of the transit occur in an order the inverse of that already described. Further, a dark phase does not take place when the satellite crosses the polar regions of the planet. After a consideration of the different explanations offered to account for these phenomena, I am myself inclined to accept that of Doctor KLEIN, which appeared in No. 2014 of the *Astronomische Nachrichten* and which has been revived by Professor HOLDEN in No. 11 of the *Publications* of the Astronomical Society of the Pacific. I propose to pay particular attention to the transits of the satellites during the current year.

THE OBSERVATORY, WINDSOR, N. S. WALES,
April 7, 1891.

SUBSCRIPTIONS TO THE MEMORIAL TO THE LATE FATHER PERRY.

The following subscriptions have been made to the PERRY Memorial Fund (see *Publ.* A. S. P., vol. ii, p. 262), and duly forwarded to the Hon. Secretary, ARTHUR CHILTON THOMAS, Esq.:

Hon. William Alvord, San Francisco, - - - - - -	$15 00
Charles Burckhalter, Chabot Observatory, - - - -	5 00
Edward S. Holden, Lick Observatory, - - - - -	15 00
Hon. Alexander Montgomery, San Francisco, - - -	5 00
E. J. Molera, San Francisco, - - - - - - - - -	10 00
Hon. W. M. Pierson, San Francisco, - - - - - -	10 00
Professor F. Soulé, Students' Observatory, Berkeley, -	5 00

ERRATA IN WATSON'S THEORETICAL ASTRONOMY.

Communicated by Professor G. C. COMSTOCK.*

Page	*Line*	*For*	*Read*
283	+ 16	n''	n'''
396	− 9	A''	A'
583	v = 69° 21'	1.7793140	1.7793135
583	69 22	1.7794862	1.7794857
592	104 48	2.1821089	2.1822089
593	108 57	2.2399235	2.2399135
601	143 24	2.9627036	2.9628036
601	143 58	2.9811226	2.9810226
601	143 59	2.9816636	2.9815636

OBSERVATIONS OF THE TRANSIT OF *MERCURY*, MAY 9, 1891, BY PROFESSOR F. SOULÉ, AT BERKELEY.

STUDENT'S OBSERVATORY, LONG. WEST GREENWICH, $8^h\ 9^m\ 2^s.36$,
N. LATITUDE, 37° 52′ 22″, BERKELEY, May 15, 1891.

PROF. E. S. HOLDEN, *Director Lick Observatory:*

DEAR SIR.—Yesterday afternoon I observed the first internal contact of *Mercury* with the sun's disc.

Mr. A. B. PIERCE, class of '90, assisted me with the FAUTH chronograph, the HOWARD mean time clock, the NEGUS sidereal chronometer and the battery and local circuits. Mr. E. P. HILBORN, '91, acted as Secretary. Mr. JOSEPH LE CONTE, JR., observed the transit through the three-inch alt-azimuth by FAUTH & Co. Mr. ANSON S. BLAKE, '91, observed with the two-inch finder of the equatorial removed to a stand in the open air. Messrs. ROSS MORGAN, '91, and L. W. LLOYD, '92, also assisted in the Observatory. I observed the transit with the 6¼-inch FAUTH equatorial, objective by the late J. BYRNE, of New York.

The full aperture was used and a Herschelian prism deflected about 12% of the rays to a Huyghenian eye-piece of power 125 furnished with a colored glass sun-shade. The telescope was driven by clock-work and protected by an improvised umbrella screen. The weather and seeing were good and the sun's limb

* Director of the Washburn Observatory, Madison, Wisconsin.

steady and sharply defined in the field, with the exception of an occasional slight shimmer.

The planet came upon the sun at the expected place, but I was not sure, and gave no signal on the chronograph until *Mercury*, by estimation, was ¼ or ⅓ upon the disc at $3^h\ 54^m\ 5^s.46$ plus clock correction $(+\ 12^s.83) = 3^h\ 54^m\ 18^s.29$. P. S. T.

Gave first signal for internal contact, which I afterward found too early, at $3^h\ 56^m\ 18^s.13$ corrected time.

Signalled again for internal contact at $3^h\ 56^m\ 44^s.69$ (corrected). This was at the stage of transit when the following limb of *Mercury seemed* just internally tangent to the sun's circumference, but there was a little shimmering at this moment.

After this the planet remained connected with the limb by a broad dark band which gradually narrowed as the motion proceeded inward, until at $3^h\ 57^m\ 42^s.21$, it broke, and a narrow bright rim of light intervened, leaving the planet completely surrounded by the bright disc of the sun.

I regard this last as the most positive and absolute of all the observations.

The time-records were made by a break-circuit key in my hand in the equatorial room recording upon the chronograph sheet in the transit room. The mean time HOWARD clock had been carefully rated and was checked the nights preceding and following the transit.

The longitude is from telegraphic correspondence with the Lick Observatory, as well as from the U. S. C. and G. Survey records. The latitude is from the latter and from zenith telescope observations.

I watched carefully for any evidence of twilight illumination around the planet's disc, and for any other atmospheric indications, but saw none. The face of the planet was at all times entirely black, and was invisible up to the moment of projection upon the sun's face. Occasionally terrestrial atmospheric disturbance would throw a flickering grayish cloud across the whole planet, but this was only for a moment. A very large fine sunspot, attended by four small ones, was a conspicuous object near the sun's center. A smaller one in the lower left hand of the field was also casually noticed, but seemed to have no penumbra. It was nearly round, although somewhat elongated in the direction of the sun's equator.

Yours very truly, FRANK SOULÉ.

OBSERVATIONS OF THE TRANSIT OF *MERCURY*, MAY 9, 1891, BY PROFESSOR C. W. FRIEND, AT CARSON, NEVADA.

From the Nevada *Tribune*, May 11, 1891, the following paragraph is taken:

"The first and second contacts of the transit of *Mercury* were successfully observed at the Carson Observatory by C. W. FRIEND, Director of the State Weather Service, assisted by D. C. GRUNOW, of the U. S. Signal Service, on May 9th, with the 5-inch equatorial and chronograph. Time of first contact, Pacific Standard Time (obtained from star transits on May 8th and 9th), $3^h\ 53^m\ 39^s.43$; second contact, $3^h\ 57^m\ 29^s.83$."

SKETCH OF THE TRANSIT OF *MERCURY*, MAY 9, 1891, BY A. HUNNIUS, LEAVENWORTH, KANSAS.

A sketch of the transit, as viewed by projection, was received from Mr. HUNNIUS, who was assisted by Professor W. A. EVANS. The sky was cloudy and the contacts were not seen.

OBSERVATIONS OF THE TRANSIT OF *MERCURY*, MAY 9, 1891, BY PROFESSOR KEEP, AT MILLS COLLEGE, CALIFORNIA.

The transit of *Mercury*, May 9, 1891, was observed at the Mills College Observatory, with the five-inch refracting telescope. The air was very clear and the phenomenon was distinctly seen by a number of observers. The planet stood out as a small black sphere, clear and sharp, while nearer the center of the sun's disc was a well defined spot, with nucleus and penumbra. The spot appeared larger than *Mercury*, but the distinction between the black disc of the planet and the hazy and irregular outline of the sun-spot was very marked. JOSIAH KEEP.

OBSERVATIONS OF THE TRANSIT OF *MERCURY*, MAY 9, 1891, AT MOUNT HAMILTON, BY EDWARD S. HOLDEN AND JAMES E. KEELER.

Instruments.

The 36-inch equatorial was used with its full aperture, and a polarizing eye-piece by FAUTH & CO. The eye-piece used for the contacts magnified about 350 diameters. The field of view was quite small. The first contact was observed by Professor

KEELER with the long-finder (four inches aperture, magnifying power about 110 diameters). It was not possible to see the same part of the sun in this finder and in the 36-inch at the same time, and, accordingly, it was determined to observe the first contact with the 4-inch and the second with the 36-inch.

The ingress was to take place abont 3^h 54^m, P. S. T. (8^h slower than G. M. T.), and the planet was looked for about 3^h without success. The field of the polarizing eye-piece was too full of glare for any hope of seeing *Mercury* projected on the corona.

At about 3^h 47^m Professor KEELER took his place at the 4-inch and endeavored to see the planet before ingress, without success. The air was very unsteady. (Wt. = 1.) The first contact was noted at 11^h 14^m 44^s, Chron. 1720 = 3^h 53^m $32^s.5$, P. S. T. The observers' note was "contact certainly but very little late."

The planet was immediately placed in the field of view of the 36-inch telescope, and the ingress was watched by Professor HOLDEN. There was not the slighest trace of the planet outside of the limb of the sun between contacts I and II (nor at any other time). The atmosphere was extremely unsteady, and it was determined to note a series of times, corresponding to various phases of ingress, and to select the adopted time of contact II from among them. Accordingly, it was recorded that—

II (*a*) the cusps first meet at 11^h 18^m $53^s.5$, Chron. 1720 = 3^h 57^m $41^s.3$, P. S. T.

II (*b*). The internal tangency is complete at 11^h 19^m $3^s.5$, Chron. 1720 = 3^h 57^m $51^s.3$, P. S. T.

It was not, however, found necessary to record any other times than these. The time of contact II is the second time above given. For more than an hour after ingress the planet was carefully examined by both observers on the sun's disc. The sky was cloudless, rather milky, but the images were unsteady, although considerably better than at ingress. Magnifying powers of 350 and 570 were employed. The planet was perfectly round, and in the best moments sharply terminated. The granulations of the sun's surface were fairly well seen at times, as also the details of a large sun spot. Not the slightest trace of a satellite was seen; and both observers were confident that no such body could then be on the sun's face and escape detection, unless it were exceedingly minute.

Chronometer Comparisons.

	h.	m.	s.	h.	m.	s.	
Chron. 1720,	9	59	30.0 =	2	38	30.0,	Howard Clock
" "	11	24	15.0 =	7	10	2	Dent "
" "	11	25	32.0 =	4	4	18.0,	Howard "

HΔt = $+0^s.75$; δT = $+0^s.12$. Dent. Δt = $-3^m\ 32^s.65$;
δT = $-0^s.35$.

Results of Observation.

The positive results are the following times for ingress:

	h.	m.	s.	
Contact I	3	53	32.5,	P. S. T. (J. E. K.)
" II	3	57	51.3,	" (E. S. H.)

For comparison, the following data are quoted:

	h.	m.	s.	
Contact I	3	53	14.5	(J. M. S.)
" I	3	53	7.0	(E. E. B.)
" II	3	57	53.5	(J. M. S.)
" II	3	57	54.2	(E. E. B.)

REPORT ON VISUAL AND PHOTOGRAPHIC OBSERVATIONS OF THE TRANSIT OF *MERCURY*, MAY 9, 1891, AT MT. HAMILTON, PREPARED BY J. M. SCHAEBERLE.

The conditions for securing good photographs of the transit with the 40-foot horizontal photoheliograph were not favorable, because the rays from the sun passed close to the roof of the main building, even at the ingress of the planet (hour angle 4 hours). It was necessary to stop the photographic work about an hour after ingress on this account. In spite of this drawback, it was desirable to secure a number of negatives.

Accordingly, at Professor HOLDEN's request, I put this instrument in adjustment. It is unnecessary to give in detail the various operations, as the adjustments were made in precisely the same way as described in my "Report on the Solar Eclipse of January 1, 1891." One change, however, was made. The metallic plate-holder was originally so constructed that only a square plate of a particular size (7½ by 7½ inches) could be employed, and as such plates could only be obtained on a special order, thus involving needless time and expense, a portion of the frame was cut away, so that an 8x10 plate could at once be placed in precisely the same plane as that occupied by the original square plate. This change is a decided improvement, as the plates can now be inserted, exposed and removed in two or three seconds of time; the portion of the dry-plate projecting above the plate-holder affords an easy and quick way of handling the plates.

The slit in the drop-shutter was made about half an inch in width, and the velocity during exposure was that acquired by the shutter first falling freely through a distance of about two feet before admitting the solar rays.

A trial exposure, made by Mr. BURNHAM and myself on May 8th, resulted in an excellent negative of the sun, the atmosphere being unusually steady for daylight observations.

On the morning of the 9th I repeatedly examined the place where *Mercury* was known to be, using the 6½-inch CLARK telescope for this purpose, in the hope of being able to detect the planet, but the search was fruitless. Towards noon the sun's image was as unsteady as we usually see it here in the daytime in a clear sky.

When first seen with the 6½-inch telescope (aperture reduced to three inches) the planet had already made a slight indentation in the sun's limb, so that I was, of course, several seconds late. I waited a few seconds to make sure that the phenomenon, which, according to the predicted time, was about one minute early, was not due to the bad condition of the seeing, and then gave the signal to Mr. BURNHAM, who was within the photographic house, to make the first exposure. I observed the second contact with the same equatorial, but, owing to the low power (65 diameters) used and the bad seeing, the time of this contact may be several seconds in error.

The work from this time on was chiefly with the photoheliograph. With this instrument thirteen exposures were made. Mr. S. W. BURNHAM manipulated the plates and shutter. Mr. A. J. BURNHAM was stationed at the heliostat, and kept the sun's image properly centered; the chronometer times of exposure were recorded by myself; these times were also automatically recorded on the chronograph, using Clock No. 4; the correction to this clock being found by interpolation from two sets of time observations, one made on the night of May 8th by myself, the other on May 9th by Mr. KEELER.

Four of the thirteen negatives secured during the transit were doubly exposed near the lower edge of the sun's image, owing to the rebound of the shutter. As, however, the image of the planet does not fall within the doubly exposed segment, these plates are still available for exact measurements. On some of thc plates the distortion of the planet's disc, and the serrations in the limb of the sun, plainly show the effects of the atmospheric disturbances, aggravated, no doubt, by the hot air rising from the metallic roof, above which the solar rays, forming the image, passed.

The Pacific Standard Times of Contact, as observed by me are as follows:

1st Contact $3^h\ 53^m\ 14^s.5$. Certainly several seconds late.
2d Contact $3^h\ 57^m\ 53^s.5$. May be several seconds in error, either way.

The Pacific Standard Times of Exposure of the Photographs taken with the 40-foot telescope are given in the following table:

Negatives of the Transit of Mercury.

Plate.	P. S. T. of Exposure. h. m. s.	Remarks.
1	3 53 22.1	Slight trace of indentation. Lower part of sun's image doubly exposed.
2	3 56 0.6	A very decided notch. Lower part of sun's image doubly exposed.
3	4 8 43.8	
4	(4 19 23.6)	Times doubtful.
5	(4 20 46.7)	Times doubtful.
6	(4 25 23.8)	Times doubtful. Lower part of sun's image doubly exposed.
7	4 27 35.6	Lower part of sun's image doubly exposed.
8	4 40 56.6	
9	4 48 20.1	
10	4 54 56.6	
11	5 6 11.0	
12	5 9 41.7	
13	5 13 36.7	

For Plates 4, 5 and 6 the chronometer times were not noted, and as there are several false records on the chronograph sheet, the ones selected may be erroneous.

For reducing these photographs the following constants, which were determined near the date of the transit, will be necessary.

Azimuth of the optical axis passing through the middle vertical line (the line nearest to, and on the east side of the plumb line) of the glass reticule in the focus of the 40-foot telescope.	$= + 22''.3$
Altitude of the upper edge of the letter *B* in the word *OBS* engraved on the same reticule.	$= + 14''.0$
Sum of the two jaw-micrometer readings at 55° Fah. being the sum of the distances from the ends of the measuring-rod to the nearest glass surfaces.	$= 12^{in.}.65$

The interpolated values of the meteorological constants for the time of transit are approximately, Bar. $25^{in.}.84$, Att. Ther. 63°, External Ther. 61°.

The plates were developed by Mr. S. W. BURNHAM a day or two after the transit.

MOUNT HAMILTON, May 27, 1891.

OBSERVATIONS OF THE CONTACTS, DIAMETER AND POSITION OF *MERCURY*, AT THE TRANSIT OF MAY 9, 1891, AT MT. HAMILTON, BY E. E. BARNARD.

The transit of *Mercury* was observed with the 12-inch equatorial of the Lick Observatory. Though the day was perfectly clear, the atmosphere was very unsteady.

At the request of Professor HOLDEN I have prepared the observations for the *Publications* of the Astronomical Society of the Pacific.

After experimenting with various apertures the 12-inch was cut down to four inches, as with larger apertures the dark glass became uncomfortably heated.

Near the time of first contact *Mercury* was repeatedly and carefully looked for with magnifying powers of 150 and 175. For this purpose a very thin dark glass was used, which cut off the glare of the sky without unduly obstructing the view—the sun being kept just without the edge of the field. Up to four or five minutes before first contact no trace of the planet was visible. A darker glass was then substituted, and a further watch kept at the point of contact. A small section of the sun's limb was cut off with the micrometer wire at the position angle predicted by Professor SCHAEBERLE (*Pub.* A. S. P., vol. III, p. 67). The planet was caught sharply at the predicted point. It was seen for two seconds before the notch was certain; the time was then recorded as $3^h\ 46^m\ 34^s.7$, as the contact was visible two seconds earlier than this (as counted by the ticks of a telegraph sounder), I have subtracted two seconds from the above as the time of first contact.

For the second contact; at $3^h\ 51^m\ 7^s$, I recorded: "Not quite separate." The moment of second contact ($3^h\ 51^m\ 19^s.9$), was quite decided, there not being over one or two seconds of uncertainty. At $3^h\ 51^m\ 29^s$ "clearly separate" was recorded. I made also an estimate of the time when the planet was half on the sun; this was at $3^h\ 48^m\ 34^s$, and is quite uncertain, from the unsteadiness of the air. Following are the adopted times of contacts:

First contact,	1891,	May 9th,	$3^h\ 46^m\ 32^s.7$,	Mt. Hamilton,	M.	T.
Second	"	"	$3^h\ 51^m\ 19^s.9$,	"	"	"

Only that portion of *Mercury* projected on the sun could be seen. No trace of an atmospheric ring was visible, neither during the entrance on to the sun nor while in transit. No white spot (sometimes reported at transit), could be seen, the planet appearing uniformly black. The *black drop* was not present at second contact. An unsuccessful search for a satellite was made.

Mr. BURNHAM made some successful photographs with the 12-inch during the transit, the micrometer being removed and the aperture reduced to one inch. These show the planet well, as also several sun-spots, the umbra of one of which measured 18″.

As the transit afforded an opportunity for the accurate determination of the diameter of the planet, I decided to make a series of measures.

It was proposed to measure the diameter by making the edges of the wires externally and internally tangent to the disc of *Mercury*.

Practically, however, from the agitated condition of the air, it was found best to bisect the limbs with the middle of the wires, which could be done quite accurately. The measures were all double distances, and the eyes were kept parallel to the equator.

From these measures I have determined the following values for the apparent diameter of *Mercury*. They are corrected for refraction:

Mount Hamilton, M. T.

1891, May 9th, $4^h\ 50^m$	Polar Diameter,	$10''.80 \pm 0''.07$	22 observations.
	Equatorial Diameter,	$10''.83 \pm 0''.05$	22 observations.

"Polar" in this case refers to the diameter perpendicular to the celestial equator, and "equatorial" to a diameter at right-angles to that. Though the equatorial diameter comes out slightly the larger, I should not consider it necessarily due to any polar compression. These were measured with powers of 150-175–500.

Reduced to distance unity, these values become:

Polar = 6″.01 ± 0″.04.
Equatorial = 6″.02 ± 0″.03.

It was my intention to make a series of measures of the differences of right ascension and declination of *Mercury* and the limb of the sun, but the field of view was not sufficiently large to permit this being done with any degree of accuracy. I therefore made direct measures between the nearest limbs of *Mercury* and the sun. The wires were carefully adjusted to appear perpendicular to the line joining *Mercury* and the sun's limb. The position angle of the point measured from was deduced from the readings of the position circle at the time of observation. From the nature of the case the position angles given may be as much as a degree in error, which will have no sensible effect upon the measured distances. To the values thus obtained I have added 5″.4, the semi-diameter of *Mercury* deduced from my measures. These give:

Mount Hamilton, M. T.

1891, May 9th,	$5^h\ 3^m\ 24^s$	$\Delta = 2'\ 26''.5$	(4. obs.)	$p = 133°.6$
" "	5 42 48	$\Delta = 3\ \ 7\ .0$	(4. obs.)	$p = 144\ .0$
" "	6 1 31	$\Delta = 3\ \ 15\ .8$	(3. obs.)	$p = 149\ .4$

which are the apparent distances between the center of *Mercury* and the point on the sun's limb whose position angle is p. These are corrected for refraction.

During the observations the seeing ranged from 1 to 3 on a scale of 5 for perfect seeing.

In a recent article on the diameter of *Mercury* (*Astronomische Nachrichten*, No. 3034) Dr. L. AMBRONN, of Strassburg, has given a valuable table of the measures of the planet which have been made by different astronomers.

I copy this table here, and have added to it my own measures, to complete the list. The values for the diameter are all reduced to distance unity:

DOUBLE IMAGE MICROMETER.

(*During Transit.*)

No.	Year.	Astronomer.	Diam. Mercury.
1	1832	Bessel	6″.679
2	1868	Wolf	6 .229
3	1868	Plummer	6 .07
4	1868	Copeland	6 .644
5	1878	Todd	6 .604
6	1878	Schur and Hartwig. ..	6 .802
		(*On the Sky.*)	
7	1865	Kaiser	6 .606
8	1890	Ambronn	6 .597

FILAR MICROMETER OR OTHER MEANS.

(*During Transit.*)

No.	Year.	Astronomer.	Diam. Mercury.
9	1848	Hind	6″.268
10	1861	Schmidt	6 .877
11	1861	Hartnup	6 .83
12	1868	Maclear	5 .65
13	1868	Börgen	6 .48
14	1878	Krueger	6 .205
15	1878	Bruhns	5 .900
16	1878	Peter	5 .968
17	1878	J. G. Lohse	6 .467
18	1878	Copeland	5 .961
19	1878	Carpenter	6 .942
20	1878	Maxwell Hall	6 .537
21	1891	Barnard	6 .015
		(*On the Sky.*)	
22	1882	De Ball	7 .456

E. E. BARNARD.

MOUNT HAMILTON, June 1, 1891.

NOTE ON THE VISIBILITY OF *MERCURY* DURING TRANSIT.

On the day of transit, Mr. BURCKHALTER, of the Chabot Observatory, made some interesting experiments in regard to the visibility of the planet.

He found that it could be distinctly seen with a small telescope, or one-barreled opera glass, with a magnifying power of 2½ diameters (O. G. = 1.38 in. focus 5 in.).

I have not seen elsewhere anything in regard to this subject and was always under the impression that a somewhat larger power was required to see the planet.

As *Mercury* was wholly invisible to the unaided eye on May 9, I have thought that some further experiments in this same line might be of interest, in determining how small a magnifying power would really show the planet.

The experiments were made with a glass positive from one of Mr. BURNHAM'S negatives of the transit made with the 12-inch. Perhaps this method is better than to use a black spot on white paper to represent the planet.

With this projected against the bright sky, *Mercury* was just visible with the eye at 96 inches, while the limit of visibility with Mr. BURCKHALTER'S glass (kindly loaned for the purpose) was 246 inches.

The image of the sun on the positive was 1.7 inches. At 183 inches this would subtend the same angle as the sun in the sky.

Assuming the conditions the same, it is evident that *Mercury* could not be seen in transit with the naked eye, but it appears that a power of two diameters should just show it. It was actually seen by Mr. BURCKHALTER with 2½ diameters.

On this photograph is shown a considerable sun-spot. This was visible at a distance of 25 feet. It would appear that the spot should have been visible to the naked eye, though I did not so see it on the 9th. Measurements at the time of transit made the diameter of its somewhat irregular umbra = 18″ and the penumbra 34″.

E. E. B.

OBSERVATIONS OF THE TRANSIT OF *MERCURY*, MAY 9, 1891, BY CHARLES BURCKHALTER, OAKLAND, CAL.

CHABOT OBSERVATORY, OAKLAND, May 9, 1891.

I observed the transit of *Mercury* with the full aperture of the 8-inch equatorial, using the power of 150 and a HERSCHEL prism. The following times are given in Standard Pacific Time, the longitude of the Observatory being $8^h\ 9^m\ 6^s.62$ W. from Greenwich, as telegraphically determined by the U. S. C. and G. S.:

	h.	m.	s.	
Time of 1st contact,	3	53	19.5.	Seeing first-class.
Time of 2d contact,	3	57	59.9.	Seeing good.

I saw no evidence, whatever, of "black drops," excepting about thirty seconds before second contact, when the sun's limb was boiling badly, when it was seen for a few seconds—in fact—during the time of greatest disturbance.

I obtained my time by transit observations of stars on the nights of May 8th and 9th.

I availed myself of this opportunity to determine, as near as possible, the lowest optical aid required to see the planet on the sun's disc. I have a small telescope with $1\frac{4}{10}$-inch objective and 3.2 inches focal length, giving a power of (as near as I can determine) two and one-half diameters. This was attached to the finder of the 8-inch equatorial, the driving-clock of which greatly assisted in bringing out its full power. I was assisted by three young men from the Oakland High School, who had had some little experience in observing.

When the planet was well on the sun's disc, each one made an effort to find it with the small telescope, but, as they were ignorant of the planet's position, and did not know whether the telescope was inverting or not, they all failed to find it, although each one found the sun-spot near the planet. After cautioning them to look for *Mercury* near the limb of the sun, and giving them the position—*i. e., the quadrant*—in which he would be found, Messrs. TAYLOR and YOUNG found the planet, and correctly drew his position, while Mr. GUPPY failed entirely, even with a diagram before him, giving the planet's position.

I saw it myself, distinctly, but a knowledge of its position, no doubt, materially aided me, and would certainly not have seen it without very close scrutiny. CHARLES BURCKHALTER.

OBSERVATIONS OF THE TRANSIT OF *MERCURY*, MAY 9, 1891, BY W. C. PARMLEY, OGDEN, UTAH.

OFFICE OF W. C. PARMLEY, CITY ENGINEER AND BUILDING INSPECTOR, OGDEN, UTAH, May 12, 1891.

I made some observations of the transit of *Mercury* on the 9th and, though they may not be accurate enough to be of much use to you, I will send them.

I observed with a $1\frac{7}{8}$-inch telescope of 45 diameters magnifying power; Mr. BOSTAPH, my assistant, with an engineer's transit, 1-inch glass and 25 diameters magnifying power.

My time was taken from the Western Union time signals, as they came from Washington, at 10 o'clock. My watch on the

11th was only one second different from what it was on the 9th, so I did not apply any rate correction.

I computed the exterior ingress contact; and the interior contact I obtained by adding the difference given in the Ephemeris.

Computed times, as well as those observed, are as follows:

	Exterior.			Interior.		
	h.	m.	s.	h.	m.	s.
Computed,	4	54	21.2	4	59	16.9
PARMLEY,		54	14.0		59	06.0
BOSTAPH,		54	14.0		59	04.0

In computing I used the latitude and longitude for Ogden given in the Ephemeris, though my place of observation was one and one-quarter miles east of the old observatory.

I expect to compute and observe the eclipse of June 6th, and will send the results, if they have any value.

W. C. PARMLEY.

P. S. (May 21.)—I have triangulated carefully the distances from the Latitude and Longitude Observatory Pier to the City Hall, and the distances are as follows to where my telescope was—6394 feet east and 69 feet north. These measures are probably correct within three feet. Mr. BOSTAPH was stationed about eight feet south of me. I find the marks on the pier slightly different from the values given in the Ephemeris. They are: Longitude 111° 59′ 54″.64; latitude 41° 13′ 08″.56. I do not know the cause of the difference.

OBSERVATIONS OF THE TRANSIT OF *MERCURY*, MAY 9, 1891, BY C. W. IRISH, RENO, NEVADA.

RENO, May 16, 1891.

PROF. E. S. HOLDEN: I have duly received yours of the 13th inst., and as you state your intention to publish my report of observations of the partial transit of *Mercury* made by myself on the 9th inst., by the aid of Mrs. IRISH as time-reader, I deem it best to rewrite said report and condense it as much as I can.

First contact came on while the sun's limb was very much agitated by puffs of cold air, coming from a southwest direction, and the first sign I saw of the planet was at $3^h\ 54^m\ 00^s.031$, and I had, one and one-half seconds before this, been looking at the exact point of contact, but, owing to the remoteness of the sun's limb, did not see the planet. So I place the latter time at

$3^h\ 53^m\ 58^s.531 \pm 0^s.3$, and believe that had it not have been for the agitation of the sun's limb I should have seen *Mercury* then, if not in contact, certainly about in that position. The notch, made at the former time, flashed, as it were, into sight upon a partial cessation of quivering in the air.

At $3^h\ 55^m\ 08^s.67$ could distinctly see the whole of *Mercury's* disc, at which time, I judged it about bisected by the sun's limb.

At $3^h\ 56^m\ 25^s.905$ I judged the limbs of the sun and *Mercury* accurately tangent. (2d contact.)

At $3^h\ 57^m\ 15^s.65$ saw what I took to be a line of light between the limbs, but as I afterwards saw what I took to be a very delicate line of light encircling the planet's disc, it may have been this which I saw at this time.

At $3^h\ 57^m\ 27^s.77$ certainly saw the cusps of sunlight meet around the planet's disc, and,

At $3^h\ 58^m\ 06^s$. saw the planet fully upon the sun's disc with as much as 2″ space between limbs.

The air was very clear, no clouds being in sight; the only thing in the way of very accurate observations was the disturbance of the sun's limb by puffs of cold air, and they were intermittent.

I saw a copper-red, trapezoidal spot on the planet's disc, and could make out at intervals the encircling line of light before spoken of.

I saw that the planet's disc was not black, but had a grayish hue, it appearing of a lighter gray at the center. The times given are 120th meridian time, taken from the telegraphic signals sent out from the Lick Observatory on the 8th, 9th and 11th instants.

Very respectfully,

(See page 242.) CHAS. W. IRISH, *Civil Engineer.*

OBSERVATIONS OF THE TRANSIT OF *MERCURY*, MAY 9, 1891, BY WILLIAM S. MOSES, SAN FRANCISCO.

[Mr. MOSES kindly sent to the Lick Observatory a letter describing his observations together with a drawing of the phenomena showing two phases at ingress and the position of the planet at 5 and 6 P. M. The following abstract gives the necessary data.]

Place of Observation: Masonic Cemetery, San Francisco; the latitude and longitude are given by Mr. MOSES on the authority of Mr. WM. M. PIERSON, as follows:

North Latitude . . . . 37° 46′ 15″.
West Longitude . . . 122° 26′ 30″.

Instrument: 7½-inch Reflector made by J. A. BRASHEAR, of Allegheny.

Observer: WILLIAM S. MOSES.

Watch-Correction: One-third second slow, as determined by Mr. F. H. MCCONNELL, by comparison with his clock, which is daily compared with the L. O. time signals.

The time-signals require the further correction $+ 0^s.75$ hence the watch-correction was $+ 1^s.08$, which has been applied.

Observations: The sun's image was projected on white paper inside of a dark box so as to be 5⅝ inches in diameter. The first notch in the limb was noted at $3^h\ 54^m\ 29^s$, and the second phase noted was when a ring of light (about one-fifth of the diameter of the planet in the sketch) had been formed, at $3^h\ 58^m\ 26^s$. These times require the correction above given. Drawings of the various groups of sun-spots are given also. The first contact was well seen; the second phase was not so satisfactorily observed.

OBSERVATIONS OF THE TRANSIT OF *MERCURY*, MAY 9, 1891, BY WILLIAM M. PIERSON, SAN FRANCISCO, CAL.

I observed the 1st and 2d contacts of *Mercury's* transit to-day.

My observatory is in—

Latitude . . . . 37° 47′ 39″.52 N.
Longitude . . . 122° 25′ 19″.99 W.

Observation made with 8½-inch reflector equatorially mounted. Power used 25.

Clock set to P. S. time obtained from F. H. MCCONNELL at 2 P. M. [This requires the further correction of $+ 0^s.75$.]

Observation made on bristol-board screen 18 inches from eye-piece.

From $3^h\ 50^m$ until after second contact limb of sun very unsteady but at moments definition good.

First contact, limb unsteady, time $3^h\ 54^m\ 22^s + 0^s.75$.

Until planet half on disc it presented the appearance of parallelogram projected at right angles to the sun's limb. From that time to second contact disc of planet of normal shape.

Second contact $3^h\ 57^m\ 42^s + 0^s.75$. Limb very unsteady and I suspected that that was cause of second contact occurring apparently earlier than predicted, but within five seconds afterwards the definition was momentarily good and could perceive line of light between planet and limb. Unless this was effect of planet's atmosphere the second contact occurred at the time above given.

A fine sun-spot, about 10′ from planet at ingress, lent interest to the phenomenon. WM. M. PIERSON.

OBSERVATIONS OF THE TRANSIT OF *MERCURY*, MAY 10, 1891, BY PROF. T. C. GEORGE, UNIVERSITY OF THE PACIFIC, COLLEGE PARK.

[From a note by Professor GEORGE, the following data are taken.]

Place of Observation: Observatory of the University of the Pacific, whose latitude and longitude are—

North Latitude . . .	$37^\circ\ 20'\ 46''.3$
West Longitude . . .	$8^h\ 7^m\ 35^s.15$

Instrument: Six-inch equatorial by ALVAN CLARK, magnifying power, 140 diameters.

Observer: T. C. GEORGE.

Watch-Correction: Derived from L. O. time signals (which require the correction $+0^s.75$, which has been applied).

Contacts:	First Contact . . .	$3^h\ 53^m\ 5^s.8$ P. s. t.
	Second Contact . .	$3^h\ 58^m\ 0^s.8$ P. s. t.

The definition was good.

WHO DISCOVERED THE OPTICAL PROPERTY OF LENSES? [NOTES BY DR. J. L. E. DREYER, DIRECTOR OF THE OBSERVATORY OF ARMAGH, AND BY PROFESSOR SCHIAPARELLI, DIRECTOR OF THE OBSERVATORY OF MILAN.]

[Our members will recollect a question raised by Professor HANKS, and treated at some length in *Publications* A. S. P., vol. III, No. 15, page 133. It has received a solution in a private letter from Dr. DREYER dated May 15, 1891, lately received at the Lick Observatory, as follows:]

"I read yesterday, with much interest, No. 15 of the *Publications* A. S. P. I am happy to be able to tell you who HOSTIUS was, though I am afraid you will be disappointed when you become acquainted with him, for he was a most atrocious ruffian! You will find all about him in SENECA'S *Quæstiones naturales*, lib. I, cap. xvi.

"It is enough to say that he did not use a *lens*, but merely a mirror 'specula imagines longe majores reddentia, in quibus digitus bracchii measuram et longitudine et crassitudine excederet.' He lived at the time of AUGUSTUS, and no doubt it was merely a slip that AGRIPPA quoted COELIUS instead of SENECA."

Professor SCHIAPARELLI writes as follows:

MILAN, le 18 Mai 1891.

Monsieur le Professeur et honoré Collègue:

J'ai reçu votre dernière lettre et je vous suis bien obligé pour les sentiments de bienveillance dont elle est l'expression.

En lisant dans le dernier cahier des *Publications of the A. S. of the Pacific* l'article "*Who discovered the optical properties of lenses*"? et la discussion sur HOSTIUS, je me suis rappelé que l'histoire de ce curieux personnage (qu'il ne faut pas confondre avec l'auteur du pöeme *De Bello Histrico*) est racontée avec assez de details dans l'Ouvrage si intéressant de Senèque, *Quaestionum Naturalium libri VIII;* cherchez livre 1, Chap. 16. HOSTIUS QUADRA vivait du temps d' Auguste et il etait fameux par ses débauches; il obtenait *à l'aide de miroirs courbes* l'amplification apparente de certains objets. Le passage de Senèque montre qu'a cette époque on connaissait l'effet des miroirs courbes non seulement pour modifier les dimensions apparentes des objets, mais aussi pour en déformer l'image à plaisir. Il n'y est point question de lentille.

Mais il parait qu'une *lentille divergente* etait employée par NÉRON (qui etait *myope*) pour voir mieux les spectacles du cirque; du moins c'est l'interprétation plus naturelle qu'on peut donner à un passage de PLINE, *Hist. Nat.* XXXVII, 5. Il est bien certain que les anciens connaissaient d'une manière empirique et approximative l'effet des lentilles et des boules de verre sur les dimensions apparentes; ils les employaient comme *verres comburants* pour concentrer les rayons du soleil et allumer le feu.

Tous les témoignages des anciens Auteurs sur cette matière ont été recueillis et discutés aver beaucoup de compétence dans le memoire suivant: H. MARTIN: *Sur des instruments d'optique faussement attribués aux anciens:* Rome, 1871.* Ce Memoire se trouve dans le Tome IV du Recueil qui a pour titre: *Bullettino di storia delle scienze matematiche e fisiche, pubblicato da* B. BONCOMPAGNI: qui est entièrement consacré à l'histoire des sciences physiques et mathématiques.

J'ai l'honneur d'être votre très devoué,

J. V. SCHIAPARELLI.

OBSERVATIONS OF THE SOLAR ECLIPSE OF JUNE 6, 1891, AT THE LICK OBSERVATORY.

The various observations have been tabulated as below by Professor C. W. TREAT.

	First Contact.	Second Contact.	Duration.	Instrument.	Magnifying Power.
	h. m. s.	*h. m. s.*	*h. m. s.*		
E. S. HOLDEN....	6 10 18.8	7 46 51.1	1 36 32.3	$2^{in}.75$ telescope	49
J. M. SCHAEBERLE	6 10 12.0	7 46 55.0	1 36 43.0	6-inch Equatorial reduced to 3 in.	65
E. E. BARNARD...	6 10 12.2	7 46 56.3	1 36 44.1	12-inch Equatorial reduced to 4 in.	175
C. W. TREAT.....	6 10 20.0	7 46 49.0	1 36 29.0	4-inch Comet seeker reduced to 2½ in.	40

The times are civil times of the 120 meridian.

OBSERVATIONS OF THE SOLAR ECLIPSE OF JUNE 6, 1891, AT THE CHABOT OBSERVATORY, BY C. BURCKHALTER.

The Second Contact was observed at $7^h\ 48^m\ 12^s.6$ P. s. t.

CHARLES BURCKHALTER.

A note from Mr. ORRIS HARMON, of Chehalis, Washington, says that the eclipse could not be observed at that place on account of clouds.

* Dr. DREYER also gives a reference to this work. It is not in the L. O. library.

RENO, NEVADA, June 11th, 1891.

PROF. EDWARD S. HOLDEN, *Director Lick Observatory:*

DEAR SIR—I have been away from home a month, and, on my return, find yours of date May 19th awaiting me.

At the risk of being too late I answer your questions.

The approx. lat. of my station N. 39° 31′.9
" " long. of my station 119° 48′.75 G. W.

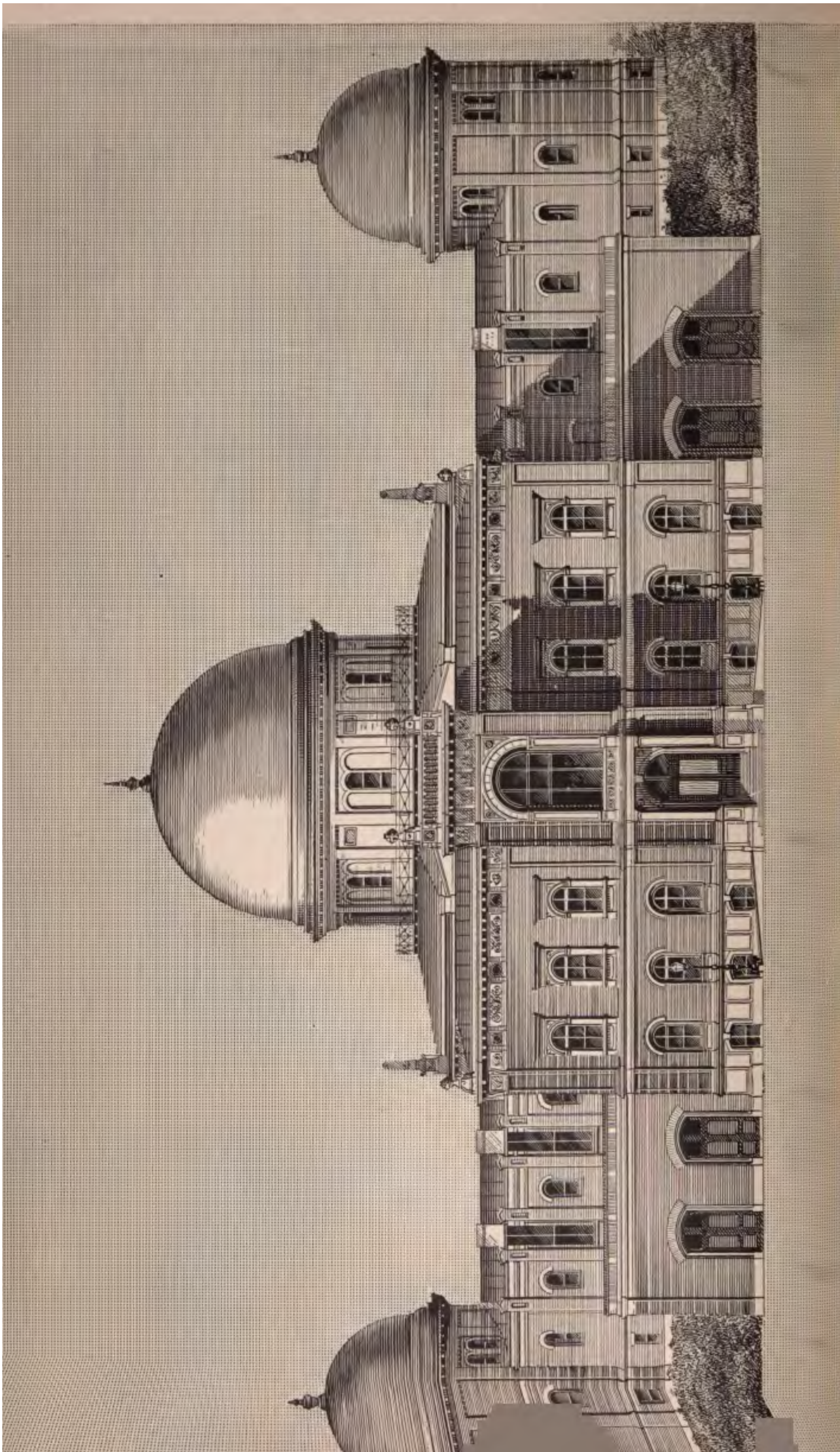
The times were taken from Mean-time Chronometer No. 602, MORRIS TOBIAS, London, regulated to Pacific Standard Time (120° Mer.), by use of the telegraphic time-signals by means of two "hack" watches at Central Pacific R. R. Office in Reno. By this means I found the rate of the chronometer as follows:

May	8th,	Telegraph	Noon	Chronometer,	slow	22.5 secs.
"	9th,	"	"	"	"	25.0 "
"	10th,	"	"	Estimated,	"	27.5 "
"	11th,	"	"	Chronometer,	"	30.0 "

This chronometer is the property of Mr. RICHARD HERR, watchmaker and jeweler of this place.

I am, very truly yours,

C. W. IRISH, *Civil Engineer.*



NOTICES FROM THE LICK OBSERVATORY.

PREPARED BY MEMBERS OF THE STAFF.

THE IMPERIAL OBSERVATORY OF VIENNA.*

The accompanying wood cuts are copied from Lieut. WINTERHALTER'S Report on European Observatories, by the kind permission of the Superintendent of the U. S. Naval Observatory. (See *Publ.* A. S. P., vol. III, page 40.) The short account here given is condensed from the text of Lieut. WINTERHALTER'S report and from other sources.

The old Observatory of Vienna was founded in 1756, rebuilt in 1826, and has been particularly active during the directorship of J. J. v. LITTROW (1819–1840). C. v. LITTROW (1840–77), and of Prof. WEISS.

Before 1877 C. v. LITTROW had experienced the difficulties of making precise astronomical observations in the midst of a great city, and as early as 1872 a site, comprising about 14 acres, was purchased in Währing, a suburb of Vienna, two miles from the center of the city. The buildings were commenced on a grand scale in 1874, and they were essentially finished in 1880. The new observatory is built in the form of a cross, with lengths of 330 feet north and south, and 240 feet east and west. The cut shows the south front, extending east and west. There are four domes (one being directly behind the great dome in the cut), all of which were built by Sir HOWARD GRUBB of Dublin. The meridian rooms are shown to the right and left of the great dome in the figure (two observing slits to the left, one to the right).

The great dome (which weighs about 15 tons) covers the 27-inch equatorial made and mounted by GRUBB. The east dome contains a 12-inch telescope by ALVAN CLARK & SONS; the west dome covers the 6-inch FRAUENHOFER equatorial of the old

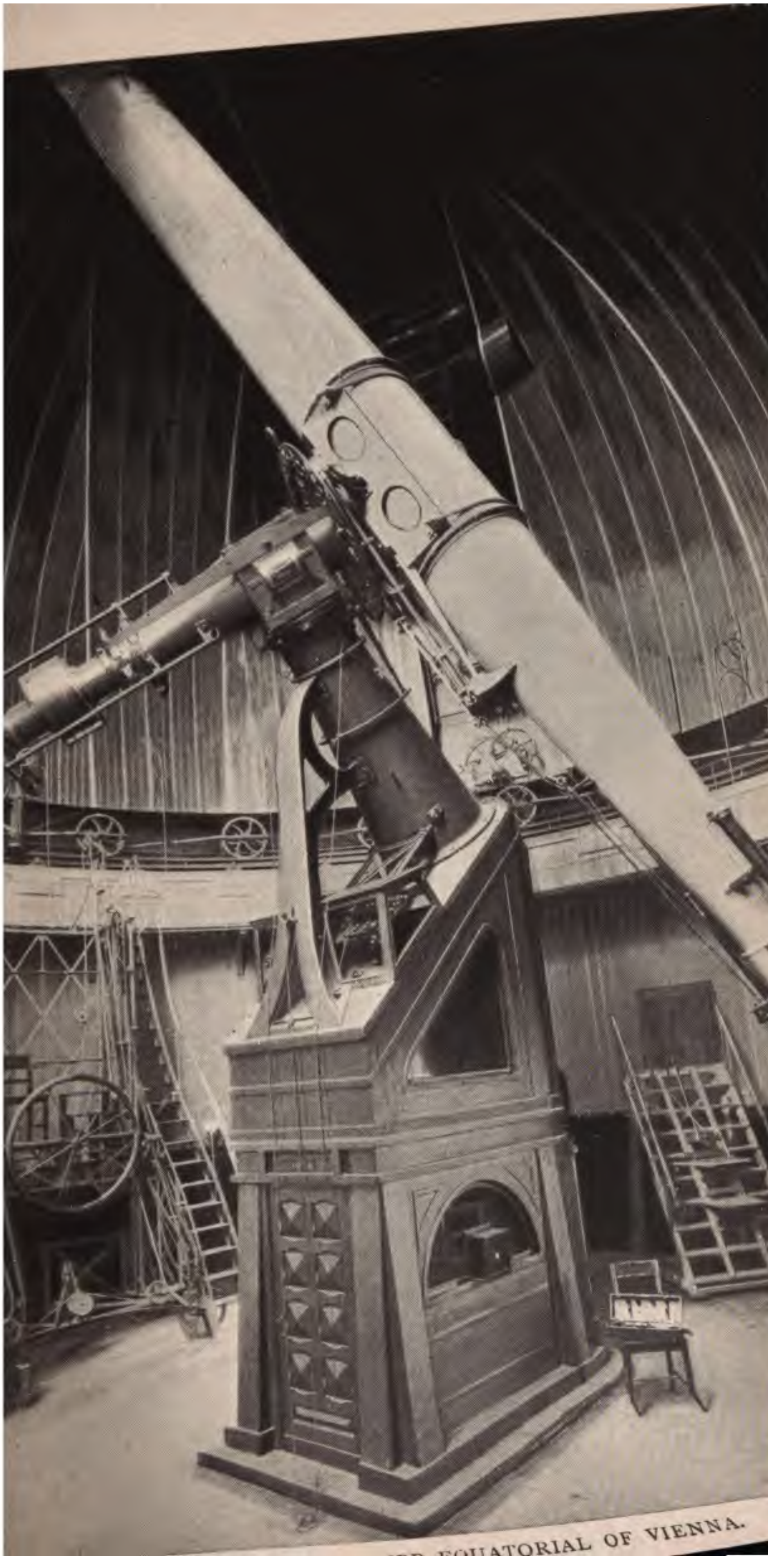
* Professor EDMUND WEISS, Director.

Vienna observatory, and the comet-seeker is placed under the north dome.

The chief instrument of the observatory, and one of the largest in the world, is the 27-inch GRUBB refractor, of which a cut is given.

Its object-glass is no doubt a good one (see Professor VOGEL's investigations of its achromatism as quoted by Mr. KEELER in *Publ.* A. S. P., vol. II, page 164), and great care was bestowed by the maker on the new problems presented by the mounting of so large a telescope. The general principle of the mounting can be readily understood from the figure. It is full of ingenious details, which have been fully described by the maker in *Engineering* (vol. 29, 1880). Its motions are said to be easy and satisfactory. In my opinion both this mounting and the admirable mounting of the 36-inch telescope of the Lick Observatory are too complex rather than too simple. It is only fair to say, however, that the 36-inch telescope has been in constant use since June, 1888, and that not a single night's work has been lost on account of any necessity for small repairs or adjustments. There is an undoubted convenience in being able, occasionally, to read the finely divided R. A. circle from the eye-end, for example. But how often is this required? In three years' experience at the Lick Observatory it has only been necessary to read the finely divided R. A. circle when the position of the instrument was to be determined. The cost of such an arrangement is considerable, and the adjustments are complex, and it hardly seems worth while to expend the money required, in order to spare the observer the few steps from the eye-end to the pier, where other microscopes are provided to give such readings, especially if the observer does not need to make this journey more than three or four times a year. It is more important to be able to read the declination microscopes from the eye-end, and the mechanical problem is much simpler.

The small incandescent electric lights now in use, have simplified the questions of illumination of astronomical instruments, to which so much attention has been paid by GRUBB, the REPSOLDS and others; but I think there is no doubt that it is practically more convenient to have more than one light about a telescope, than to keep in order the trains of prisms which distribute the light from a single lamp to various parts of a complex instrument, as the verniers, the microscopes, the position circle, etc.



...EQUATORIAL OF VIENNA.

My own experience with large and small equatorials (and with the disposition of a limited amount of money to provide for practically unlimited wants) has led me to the conclusion that some change in the ideals of instrument makers should be made. The real question is, not to solve in the best manner a certain number of complex mechanical problems, but it is to use a certain sum of money so as to produce a perfectly satisfactory instrument for practical use, and to save everything in first cost that can properly be saved. Everything saved in first cost can be utilized in endowment, and the main point in an observatory is that its instruments shall be kept in constant use, for which purpose observers are needed. Any slighting of the essentials of an instrument is unpardonable. Any unnecessary elaboration of the details is, on the other hand, useless. Although large telescopes (as, for instance, the 36-inch equatorial) have been made so that they can easily be operated by a single observer, I question whether this is a truly economical plan to follow. Two observers will always do very much more work than one, and in many cases they will do more than twice as much as one. Hence, it seems to me that true economy in designing large instruments (either equatorials or meridian circles) is to put all the expense of time and money on the essential features (the bearings of the axes, the driving clock, etc., etc.), and to cut off every unnecessary appliance. The money thus saved will pay the salary of an intelligent aid. With a large equatorial, for example, it is necessary to be able to set the telescope quickly upon an object. Ninety-nine times in a hundred that object can at once be recognized in the finder, or, at least, in a low-power eye-piece on the main instrument (a double star, a comet, a nebula, for example). A setting to the nearest 10′ in Decl. and 1^m in R. A., suffices for the vast majority of cases like these, and such a setting can readily be made on coarse painted circles divided to 1° in Decl. and 5^m in R. A. I doubt if Mr. BURNHAM has used any circles but our coarse circles during the whole time of his connection with the Lick Observatory, and he has found and pointed on thousands of double stars. If it is necessary to identify an object which is too faint to be distinguished in the finder, the quickest method will always be to make a small sketch map from a star chart. With this chart in hand the telescope can be *accurately* set in Decl. from the eye-end and to the nearest 0.5 *m.* in R. A. by the coarse hour circle. A very little sweeping in R. A. with the low-power eye-piece brings the configuration of stars into the center of the field. The fine R. A. circle does not need to be read with large instruments, unless in very exceptional instances. The principles which govern in these cases, also obtain in many others. To read a vernier it is essential to have a beam of light fall in a given direction. It is often very much easier (and far less expensive) to make a little stand on which a hand lamp can be set, when necessary, than to provide and adjust a train of optical prisms which shall take a beam from a single lamp, divide it into separate beams, and turn these round various corners, and finally deliver *sufficient* light at a point thirty feet away from the original source. Such mechanical and optical problems have been solved with great ingenuity by Sir HOWARD GRUBB, the REPSOLDS, WARNER and SWASEY, and many other artists, but, in quite a number of instances, at least, it has been a mechanical, and not an astronomical, problem, that has been attacked.

For large instruments the services of an assistant are required, and if such services are available there is no necessity for some of the more refined mechanical devices. When the equatorial is of moderate dimensions (10, 12, 16 and 20 inches in aperture) then every possible convenience should be provided, for the services of an assistant are seldom available or necessary. A telescope as large as the Princeton equatorial (23-inch aperture) really requires an assistant to aid the observer, especially in delicate work, like spectroscopy. The same principle governs with meridian instruments. With the smaller circles (4, 5 inches) one observer is sufficient. With the larger instruments (7, 8, 9 inches, for example), it is a positive economy to have two observers work together, one at the telescope, the other at the microscope.

I have taken this occasion to speak of these matters because it appears to me to be a very important thing to limit and define the ideal of the artist who makes the instrument (and who, more or less, is solving purely mechanical problems) by the experience of the observer who is willing to take the necessary pains to secure a satisfactory result. And these remarks must be understood to apply chiefly to instruments of large dimensions, where the services of a skilled assistant are required in any event, and where such services can be utilized to do away with the necessity (and with the cost) of complex devices of one kind and another. The real test of a device is whether it is actually used, not whether it might be used; or, rather, whether one could not easily do without it.

THE 26-INCH CLARK EQUATORIAL OF WASHINGTON.

The large telescope at Vienna has made important observations of comets too faint to be seen with smaller instruments, as well as asteroid observations of the same kind. Experiments have been made in photographing with it, and these are still in progress. A list of double stars has also been observed.

For comparison, or rather contrast, with its mounting, I insert a cut of the 26-inch telescope at Washington, which we owe to the courtesy of Captain McNAIR, Superintendent of the Observatory. The mounting is by ALVAN CLARK & SONS, and is too light and too simple, rather than the reverse. It has, however, serv d its purposes admirably, for the past seventeen years, in the skillful hands of Professors NEWCOMB and HALL.

The 12-inch CLARK telescope at Vienna has been employed in the discovery and observation of asteroids in the completion of PALISA'S Ecliptic Charts and in comet observations. This object-glass is a very fine one in every respect.

The Observatory possesses a REICHENBACH meridian circle, made in 1825, and a 5-inch prime vertical transit by STARKE, also very old. Its present equipment of meridian instruments is thus very defective, as compared to its admirable outfit of equatorials. The Observatory has regularly published its observations since 1821.

E. S. H.

LIST OF EARTHQUAKES IN CALIFORNIA DURING THE YEAR 1890.

The following list contains the dates and places of occurrence of earthquakes in California (and occasionally in Nevada and Alaska) during the past year. It is a continuation of the list printed in Number 7 of these *Publications*, giving the same data for the year 1889. A complete description of the different shocks will be printed in the form of a bulletin by the U. S. Geological Survey. The times are Pacific Standard Times. The Roman numerals indicate the estimated intensity of the shocks on the ROSSI-FOREL scale:

List of Earthquakes.

1890.

January 2, 8;15—Kodiak Island, Alaska.
January 11, 4:20 A. M.—Kodiak Island, Alaska.
January 15, 5:05 A. M.—Mt. Hamilton (IV–V).
January 18, 3:30 P. M.—Santa Barbara, Napa.
January 23, 4:18 A. M.—Oakland.

January 24, 1:15 P. M.—Santa Ana.

January 24, 4:30 or 5:30 P. M.—Santa Ana.

February 5, 10:15 P. M.—Pomona, Santa Ana, San Diego, San Bernardino, three distinct shocks at 10 o'clock.

February 9, 4 A. M.—Colton, San Diego, San Pedro, Pomona.

February 9, 6:04 (?) A. M.—San Bernardino. Probably same shock as the above.

February 13, 2:10 A. M.—Tehachapi. Three light, but distinct, shocks, at intervals of about twenty minutes.

February 14, 4 A. M.—Los Angeles.

February 15, about midnight—Gilroy.

April 6, 1:20 A. M.—Kodiak Island, Alaska.

April 11, 11:30 A. M. (?)—Ukiah.

April 16, 9 A. M.—Mt. Hamilton (II).

April 24, 3:36 A. M.—Mt. Hamilton (V), Berkeley, Oakland (IV–V), San Francisco, Salinas, Benicia, Los Gatos, Brentwood, Gilroy, San Jose, Hollister, Redwood City, Point Reyes, Centerville, Watsonville, Napa, Santa Cruz, Mayfield, Pajaro, San Juan, San Leandro, Livermore, Boulder Creek, Spanishtown, San Mateo, Gonzales, College Park, Merced, Port Costa, Martinez, Stockton, Carson City, Nevada.

This shock was the heaviest along the line of the Pajaro river, where some damage was done to railroad bridges and other property.

May 11, 1 P. M.—Oakland (IV) College Park (III), East Oakland (IV), San Leandro, Berkeley.

May 14, 5 and 8 A. M.—Pajaro valley. Newspapers report slight shocks almost daily since April 24.

May 16—Eruptions and earthquakes in Alaska since February 10.

June 1, 1:21 P. M.—Healdsburg.

June 29, 7:25 A. M.—Santa Rosa, Petaluma.

June 30, 11 (?) A. M.—Santa Rosa, Santa Cruz.

July 1, 12:35 A. M.—Gilroy, San Francisco.

July 4, 4:30 P. M.—Eureka.

July 24, 3 A. M.—Bakersfield.

July 26, 1:45 A. M.—Sissons, Hydesville.

July 28, 12:04 A. M.—Petaluma.

August 17, 6:50 A. M.—College Park.

August 17—Volcanic disturbance in Mono lake.

September 3, 2:20 P. M.—San Francisco, Gilroy.

"THE EARTHQUAKE AT BORDEAUX."
Copy of a Sketch by DAUMIER, by the courtesy of the Century Magazine.

September 5, 2:15 P. M.—Merced.

September 19, 12:15 A. M.—Calico, Barstow, Daggett, San Bernardino.

October 3, 1:05 P. M. (?)—Healdsburg.

October 29, 8:36:29 (IV), and 8:39:29 (III) Mt. Hamilton.

December 4, 9 P. M.—Lone Pine. A series of shocks, lasting until 11 P. M.

J. E. K.

EXAMINATION OF THE LICK OBSERVATORY NEGATIVES OF THE MOON.

In order to obtain all the information which is contained in a negative of the Moon, it is necessary to make a positive copy of it on glass, which shows the lights and shadows as they really are, *i. e.*, white as white and dark as dark. On the positive the eye can at once pick out familiar features or detect new ones, which are not readily apparent on the negative, until they have first been found in their natural colors. In making these positive copies it is usually sought to give such an exposure as will produce the best general plastic effect in the resulting plate—such as will make the best "picture," as is said. But every single feature on the Moon, and thus on the negative, has an illumination and a distinctness of its own. If we vary the exposure-times in making the copies we shall thus be able to exhibit certain special regions in a new light, which is also a true one as to form, though the photometric contrast with neighboring regions may be exaggerated. Suppose, for example, that in copying a certain negative the best general pictorial effect is obtained by exposing it for 30 seconds to the light of a lamp 18 inches distant. This makes the picture which is wanted by artists, etc., and gives the truest general effect. Some parts of this copy are necessarily much over-exposed, and some parts of it are much under-exposed, but the result is the best general average.

Now suppose that instead of confining ourselves to making this one copy of 30 seconds exposure, we make a series of copies (all at the same distance from the lamp), with exposures of 10, 20, 40, 50, 60, 70 and 80 seconds. What will be the result? We shall have a series of copies in which the photometric contrasts are all exaggerated, but in which the topographic forms are all truly kept. Nothing is shown (if proper precautions are taken) which is not in the original negative, but what *is* there is shown in new lights. All this is very familiar to photographers, no doubt, but some experiments in this direction which Mr. BARNARD has been kind enough to make for me have shown that this method is worthy of special attention, and that it is capable of producing new and important results, and of leading to veritable discoveries which can, I think, be made in no other way.

An examination of such a series of positive copies has shown me that the systems of bright, radiating streaks on the Moon can be exhibited in quite new relations. For example, it is positively stated by SCHMIDT that no one of the bright streaks about *Tycho* can be traced nearer to the crater wall than the *exterior* boundary of the gray *nimbus* surrounding the crater. The positives show more than one streak extending quite through the whole width of the *nimbus* and up to the wall. Again, certain plates of the series show quite new craters, never seen before. For example, a ruined crater ring is shown near *Copernicus*,* of which no trace can be seen in the map of SCHMIDT, etc. These features certainly exist, for, after they have been detected in the positives, they can be seen in a whole series of negatives. Many of them can never be seen with the naked eye, because the light of the Moon is too dazzling to allow faint contrasts to be seen. But they certainly exist, because they are readily visible in many negatives, taken on different nights, as soon as the positives have shown us exactly where to look for them.

I consider it a matter of some importance to have found new features of this class—as, for instance, to have discovered a previously unknown crater, which forms a part of the region round *Copernicus*, and whose history is intimately connected with the ancient history of the latter formation; but the most important matter is to have become possessed, through photographic processes, of an entirely new engine of research.

From what I have already seen, I am sure that hundreds of significant additions can be made to existing lunar maps by treating the Moon-negatives of the Lick Observatory in this way.

E. S. H.

MOUNT HAMILTON, February 4, 1891.

* It is nearly of the same diameter as *Copernicus*, its shape is more elliptic, its center is nearly in the line joining the centers of *Autolycus* and *Copernicus*, and its west wall almost touches the southeast wall of the latter crater.

PERMANENT IMPROVEMENTS AT MOUNT HAMILTON.

The Regents of the University have set apart the sum of $1000 from the capital of the Lick Fund, to be expended in providing new reservoirs, etc., and in general improvements to the water supply. This sum is sufficient to secure an adequate provision of water for all domestic uses.

The sum of $700 has been expended during the winter on repairs to our telegraph and telephone line. The line is now in first-class condition for some seven miles from San Jose, and in good condition the rest of the way. E. S. H.

APPOINTMENT OF MR. KEELER TO THE ALLEGHENY OBSERVATORY, AND OF MR. W. W. CAMPBELL TO THE LICK OBSERVATORY.

Mr. KEELER has accepted the position of Professor of Astronomy in the Northwestern University of Pennsylvania and Director of the Allegheny Observatory, and has tendered his resignation as Astronomer in the Lick Observatory, to take effect June 1, 1891. He leaves behind him at the Lick Observatory a record of admirable work admirably done, and he takes with him our best wishes for his future success in his new field.

Mr. KEELER'S resignation was presented to the Regents of the University at their May meeting and the following resolution was adopted by them:

Resolved, that in accepting the resignation of Mr. KEELER, the Regents desire to express their high appreciation of his astronomical work at the Lick Observatory and that they wish him every success in his new position.

Mr. W. W. CAMPBELL, lately Instructor of Astronomy at the University of Michigan, was appointed Astronomer in the Lick Observatory, to date from June 1, 1891.

At the June meeting of the Regents an additional Astronomer was authorized, whose chief work is to be in Spectroscopy. No appointment has yet been made. E. S. H.

ELEMENTS AND EPHEMERIS OF BARNARD'S COMET (MARCH 29, 1891).

From Mr. BARNARD'S observations of March 29, 30 and 31, I have computed the following elements of the orbit of this comet.

$$
\begin{aligned}
T &= \text{April } 27.668 \text{ Gr. M. T.} \\
\omega &= 184 \quad 30'.7 \\
\Omega &= 194 \quad 24'.5 \\
i &= 120 \quad 30'.3 \\
\log q &= 9.56164.
\end{aligned}
\left.\right\} \text{Apparent Equinox.}
$$

The Middle place is represented as follows:

$$
\begin{aligned}
& \quad C - O \\
\Delta\alpha \cos\delta &= -0'.14 \\
\Delta\delta &= +0'.26
\end{aligned}
$$

This orbit (together with an ephemeris extending to April 14) was communicated to other observatories by telegraph.

J. M. SCHAEBERLE.

MOUNT HAMILTON, April 3, 1891.

NEW RILL ON THE FLOOR OF THE LUNAR CRATER *THEBIT*, RECENTLY DISCOVERED BY PROFESSOR WEINEK IN THE LICK OBSERVATORY PHOTOGRAPHS OF THE MOON.

[Translation of a letter from Professor WEINEK] Imperial Observatory of Prague, 1891, April 9.

"* * * * * I send you with this a copy of my ten-fold enlarged drawing of *Thebit* which I have lately completed from the beautiful negative made at the Lick Observatory on August 27, 1888, and ask your acceptance of it. The copy was quickly made, but it is accurate.

Although I am very much occupied with other observations, I have made the drawing of this crater because it shows in the interior a species of *Rill* (extending from ξ to ϵ of NEISON'S map), resembling a fracture along the floor, which is not shown in the maps of LOHRMANN and MAEDLER nor yet anywhere mentioned by SCHMIDT.

This *Rill* in *Thebit* seems to divide into two branches, extending eastwardly, at its northern part, and shows on the negative even more plainly than the *Rill* which lies west of *Triesnecker*, and seems to be a formation of precisely the same character.

On the night of March 31, 1891 (when the phase was very similar to that of August 27, 1888), I was able to verify the existence of this feature with the 6-inch STEINHEIL telescope of this observatory in spite of the low altitude of the Moon (Decl. = — 25°) and the unsteady atmosphere.

An exchange of letters between Dr. KLEIN, of Cologne, and myself, has shown that the *Rill* was also quite unknown to this experienced selenographer and that nothing is to be found on the subject in the papers of GRUITHUISEN.

We have, therefore, a case of a *Rill* discovered *photographically*. It is not to be assumed, however, that the feature is newly formed since it is probably visible for a short time only, and since it is only to be seen in the early morning at a time when observations are not so diligently prosecuted.

I must add the remark that MAEDLER and NEISON have erroneously drawn the small crater which lies N. W. on the crater *Thebit* A on the *outer* wall. According to the negative it lies on the inner wall, and in such a manner that it also must be considered as a feature of the floor of the crater. (Compare SCHROETER'S description, etc.)

It is pretty correctly drawn by LOHRMANN and SCHMIDT, although the photographic plate shows that its height above the interior of *Thebit* must be quite different from SCHMIDT'S determination. * * * * * " L. WEINEK.

NOTE: It is known that Professor WEINEK is making an elaborate study of negatives of the Moon made at the Lick Observatory and regularly sent to the Observatory of Prague, and it is hoped soon to present in the *Publications* A. S. P. reproductions of his drawings (enlarged ten-fold from the original negatives), beginning the series with representations of the Crater *Archimides*.

The foregoing note on the discovery of a new *Rill* in *Thebit*, by Professor WEINEK, is an interesting proof of the value of our negatives when they are studied by an eminently competent eye. It was hoped to accompany Professor WEINEK'S note with a copy of his drawing, but it has been found necessary to omit the drawing for the present, although it will appear in due time with others of the same series. E. S. H.

TELESCOPE AND CHRONOMETER FOR SALE.

EDWIN B. ROOT, Esq. (54 William Street, New York City), administrator of the estate of the late Professor C. H. F. PETERS, of Hamilton College, has for sale a BOND'S Break-Circuit Chronometer, No. 335, and a portable telescope of the Comet-seeker construction made by HUGO SCHROEDER, of Hamburg. The telescope is of five inches aperture, with eye-pieces magnifying from 25 to 275 diameters, a ring micrometer, a diagonal eye-piece, and is conveniently mounted on a mahogony tripod.

I have myself used this telescope and it is extremely fine in all respects, particularly in the color-correction, and I can confidently recommend it to any one who wishes to own such an instrument. The price and terms of sale can be learned from Mr. Root. E. S. H.

Scientific Visitors to the Lick Observatory.

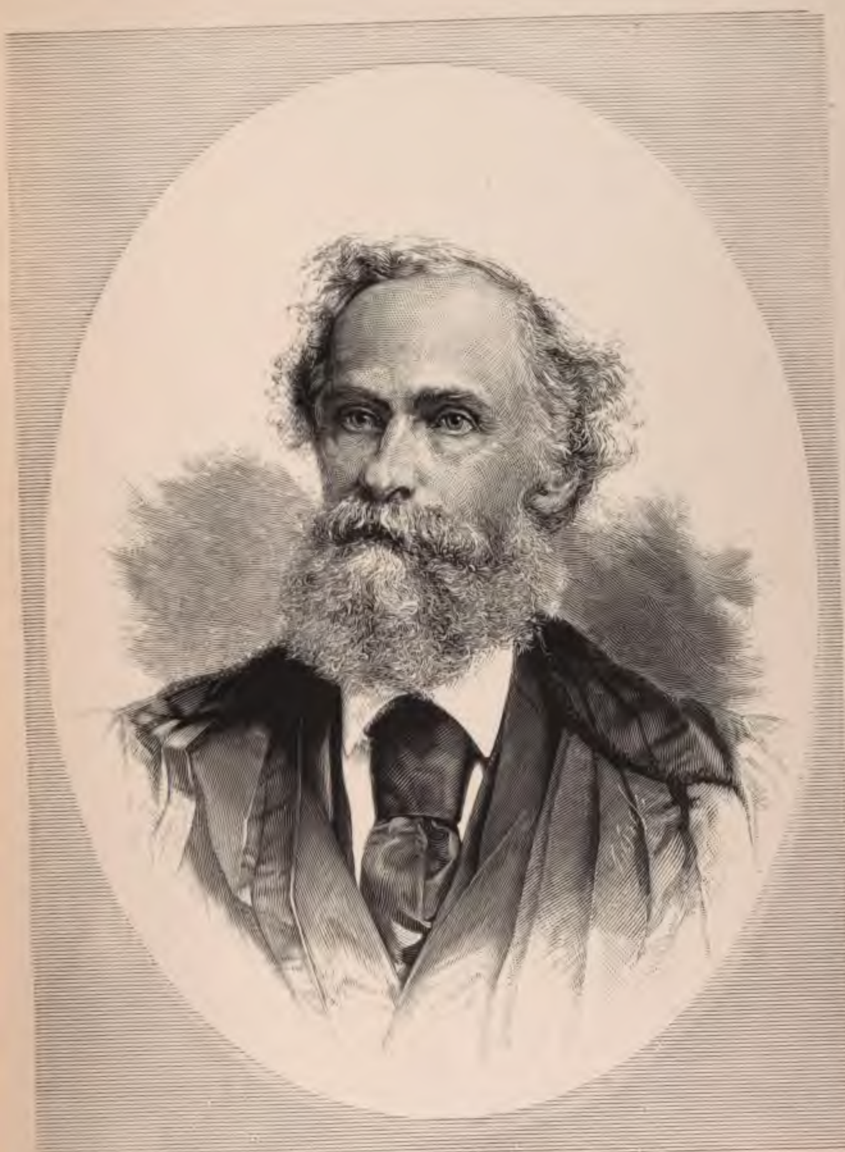
On April 28 and 29 we had the pleasure of receiving Dr. A. Marcuse, of the Royal Observatory of Berlin, and Mr. E. D. Preston, of the U. S. Coast and Geodetic Survey, who are on their way to Honolulu to engage in a series of observations for the determination of the short-period changes in the latitude (see *Publications* A. S. P., vol. II, p. 135). Mr. Preston will also determine the force of gravity at various stations in Hawaii, as Mauna Loa, etc., in connection with much other work of the kind already done by him (see *Publications* A. S. P., vol. I, p. 125). Although the season of steady vision had not yet set in and the images of stars were not to be compared with those to be had during the summer and autumn, yet the nights were clear and our guests were able to see *Saturn*, *Uranus*, some stars and nebulae and also to examine the solar spectrum with the great telescope under moderately good circumstances; as well as to make a thorough examination of the working of the dome, the moving-floor and the mounting of the 36-inch equatorial.

E. S. H.

John Le Conte, Born 1818, Died 1891.

After a long life of eminent services to Science and to Education and of strong personal influence over the many who were brought into contact with him, Professor John Le Conte died at Berkeley, April 29, 1891, at the age of 73 years. He belonged to a family many of whose members were and are highly distinguished in Science. His own scientific labors have been successively in the fields of Medicine, Chemistry and Physics, and among his numerous published memoirs there are many of permanent and lasting value. His most striking contribution to Physics was the discovery (in 1857) of the remarkable properties of "sensitive-flames" which afford a most delicate means of analysing compound musical tones. His important experiments on sound-shadows in water were wholly novel and of great value.

Almost his entire life was spent in the teaching of Science, and, since 1869, he has been the most prominent figure at our State



JOHN LE CONTE,

BORN 1818; DIED 1891.

[By permission of the Editor of the Popular Science Monthly.]

University as President and as Professor of Physics. The basis of his wide-spread personal influence was the genuine respect inspired by his gentle and upright character and by his profound devotion to learning. His daily contact with the Regents of the University, with his colleagues in the Faculties and with the students in the Colleges, continued, as it was, over a long period of years, has impressed very many different individuals under a great variety of circumstances and has set its seal upon them all; and through them upon the community at large.

Perhaps the highest service which a great teacher renders to his students is a moral one, and consists in the unconscious daily exhibition of a character and conduct which they must unreservedly respect and honor. If this is a high service, any where and at any time, it was particularly and specially serviceable during the early days of the University of California, when the educational ideals of a new community were forming.

To this task, which was often most thankless and ungracious, Dr. LE CONTE brought a patient courtesy, a high standard of thought, a scholarly devotion, which, in the end, completely vanquished active opposition and crude indifference. His last years must have given him unmingled satisfaction, for his name was honored and respected by an entire community which had come to consider him as, in a remarkable degree, the bright example of a true scholar and citizen.

It may truly be said that there is no learned Institution or Society in California whose work has not been prepared and made easier by his labors and by his influence; and in every sense and in all relations, he has deserved well of the Republic. So long as learning lasts among us his name will be honorably remembered in Science, and as one of the founders of genuine education in our midst. EDWARD S. HOLDEN.

OBITUARY NOTICE OF PROFESSOR SCHOENFELD, BY PROFESSOR A. KRUEGER; (TRANSLATED FROM THE GERMAN BY OTTO V. GELDERN.)

Professor Dr. EDWARD SCHOENFELD, Director of the Bonn University, died on the first day of May, 1891, in the sixty-third year of his age. He was born on the 22d of December, 1828, at Hildburghausen, where he attended the Gymnasium until he took up the study of engineering at the Cassel Polytechnicum. A year later he visited the Polytechnic School of Hanover for the same purpose, and attended the lectures of KARMARSCH, RÜHLMAN and SCHWARZ. Here he concluded to follow his inclination for the natural sciences, and in the autumn of 1849 entered the University of Marburg, where, after a thorough course in chemistry, he was led by GERLING into astronomical science. In the spring of 1852 he came to Bonn to continue special studies in astronomy. ARGELANDER recognized at once the extraordinary talents and the glowing enthusiasm of the coming astronomer; and when, in the spring of 1853, the position of assistant, there being only one at that time, became vacant by the removal of SCHMIDT to Olmütz, he tendered him this place without hesitation, even before his promotion, which did not take place until the summer of 1854.

ARGELANDER had already considered plans for the *Durchmusterung* of the northern heavens; the advent of SCHOENFELD, who took up the work with great zeal, soon matured these projects. During a long absence of ARGELANDER, who had journeyed to Pulkowa, the first zone observations were taken up with the small comet seeker and laid before the Director upon his return, as a sample of his work. The author of these lines had the good fortune to take part in this great undertaking, at first as a volunteer only, but later on as a permanent assistant. Happy days of trying but successful activity were begun with this work, which, under a mutual rivalry between the Director and his assistants, steadily progressed; with it SCHOENFELD was constantly connected until its completion, although called away in 1859 as Director to the Observatory at Mannheim, to which place his wife, who faithfully stood by his side and shared his joys and sorrows to the end, soon followed him.

At Mannheim he sought and successfully carried out new work commensurate with the modest means at his disposal. A study of the variable stars, begun at Bonn, was consistently continued, and the results were laid down in the two Mannheim catalogues. Aside from that, SCHOENFELD observed those nebulæ visible to the Mannheim refractor, and published a catalogue that may well serve as a model to-day. At about this time occurred the founding of the *Astronomische Gesellschaft*, in the promotion of the welfare of which he has earned such justly deserved praise, more particularly as its Secretary since 1875.

When, in the year 1875, the Bonn Observatory was left without a head by the death of the never-to-be-forgotten ARGELANDER, it was not a doubtful question who among the astronomers would be the most worthy to fill the great vacancy. SCHOENFELD stepped into this new office; he knew how to preserve the traditions of the Observatory, and with an affecting devotion to his predecessor and former teacher, continued the task in its original conception. He at once began the great work of the southern *Durchmusterung*, for which he made all the observations himself, as well as the greater part of the reductions. The over-exertion of these ten years probably laid the foundation of his subsequent illness.

It would not be fair were no mention to be made of the invaluable services rendered by the deceased at the University. When only an instructor, before his removal to Mannheim, he delivered lectures noted for their clearness, combined with the most thorough scholarship; later on, as Professor of Astronomy, he devoted the greatest care to the department of his choice. His numerous scholars are full of praise for the completeness with which astronomical laws were presented to them.

The universal knowledge of the departed was absolutely astounding; he knew how to impart information on any question, and was ever ready to converse upon subjects that were really foreign to his science, in order to instruct himself. Aided by a prodigious memory, he had become one of the best-read. and had gathered a fund of knowledge that was admired by all who came in contact with him.

What he, whose loss we lament, has been to his friends, can be best judged by the author of these lines, who was closely connected with him through a period of over thirty-eight years. He was pleasant and communicative to all, and never presumed upon his superiority; if, at times, he carried his unassuming way to excess, it gives us the assurance that there could not have been either jealousy or enmity in any one against him.

A. KRUEGER.

OBSERVATORY OF KIEL, 1891, May 2d.

GRANT TO THE LICK OBSERVATORY FROM THE ELIZABETH THOMPSON SCIENCE FUND.

The Trustees of the ELIZABETH THOMPSON Science Fund of the A. A. A. S. have made a grant to the Lick Observatory for the purpose of providing apparatus to be used in making enlarged photographs with the great equatorial. E. S. H.

Recent Important Publications.

Maxwell (James Clerk): The Scientific Papers oι Maxwell, edited by W. D. Niven: 2 volumes, many plates, Cambridge University Press, 1890. [A copy of this splendid work has been presented to the Lick Observatory by the Clerk-Maxwell Memorial Committee.]

Dunkin (Edwin): The Midnight Sky, new edition; London, 1891. (32 star-maps and many engravings.) Price, 8 shillings.

Minutes of the Meeting of the Board of Directors held at the Lick Observatory, June 13th, 1891.

Vice-President SCHAEBERLE presided in the absence of President PIERSON. A quorum was present.

The minutes of the last meeting were approved.

The following twenty-six members* were duly elected:

H. D. BACON*	960 Oak Street, Oakland, Cal.
J. H. BARTLETT	3408 Sixteenth Street, S. F., Cal.
Mrs. CAROLINE R. BEALES	Berkeley, Cal.
HENRY BOURSIN	Douglas City, Alaska.
CLARENCE CARY	59 Wall Street, New York City.
JOHN DOLBEER	10 California Street, S. F., Cal.
JAMES L. FOLEY	Cross Lane, Walnut Hills, Cincinnati, Ohio.
Hon. W. H. GALBRAITH	Santa Cruz, Cal.
J. W. GLOVER	Ann Arbor, Michigan.
H. BARRYMORE HARRISON	Jask, Persian Gulf, via Bombay, India.
E. H. HARRISON	1947 Welton Street, Denver, Colo.
Rev. H. O. HOFFMAN	Bloomington, Illinois.
LEVI JENNEY, JR.	401 California Street, S. F., Cal.
RODNEY G. KIMBALL	253 Monroe Street, Brooklyn, N. Y.
JOSEPH KLEIBER	Imperial University, St. Petersburg, Russia.
SYDNEY T. KLEIN*	Stanmore Observatory, Great Stanmore, Middlesex, England.
H. M. LEVIER	121 Haight Street, S. F., Cal.
Miss EMMA LEWIS	Care Allen & Lewis, Portland, Or.
JOHN D. LOCKE	Haverhill, New Hampshire.
ENOCH G. MEGRUE	Care J. R. Megrue, Cincinnati, Ohio.
Miss G. J. MILLER	307 Seventeenth Street, Portland, Or.
THE IMPERIAL OBSERVATORY	University of St. Petersburg, Russia.
Miss HARRIET L. PRUYN	13 Elk Street, Albany, N. Y.
ISAAC ROBERTS	Starfield, Crowboro', Sussex, England.
WM. CURTIS TAYLOR	Tacoma, Washington.
Prof. C. V. ZENGER	Smichow, Prague, Bohemia.

Owing to his departure from the Pacific Coast, Mr. KEELER presented his resignation as an officer of the Society.

The following resolutions were adopted:

Resolved: That the resignation of Mr. KEELER as Director, Secretary and member of the Committee on *Publication* A. S. P. be accepted to date from June 1, 1891, with a cordial expression of good wishes to Mr. KEELER in his new career.

Resolved: That Mr. W. W. CAMPBELL be appointed Director, Secretary and member of the Committee on *Publication* A. S. P. to date from June 1, 1891.

Resolved: That a list of names presented by the Treasurer be dropped from the list of members.

* An asterisk (*) is affixed to the names of Life Members duly elected.

The Society has lost the following members through death:

R. W. WATERMAN, JOHN LE CONTE,
GEORGE JEWETT HICKS.

Owing to the temporary closing of the rooms of the Mercantile Library, it was

Resolved: That the Library Committee be empowered to remove the books belonging to the Library of the Society to the new rooms at No. 819 Market Street.

It was ordered that a catalogue of the books in the Library of the Society be printed.

The Treasurer presented his bi-monthly report, which was received and filed. Adjourned.

MINUTES OF THE MEETING OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC, HELD AT THE LICK OBSERVATORY, JUNE 13TH, 1891.

President PIERSON being absent, Vice-President SCHAEBERLE presided.

The minutes of the last meeting, as printed in the *Publications*, were approved.

A list of presents was read by the Secretary, and the thanks of the Society voted to the givers.

The Secretary read the names of members duly elected at the meeting of the Directors.

The following papers were presented and taken as read:

a. The Solar Eclipse of June 6, 1891, by ORRIN E. HARMON, of Chehalis, Washington.

b. The Thermometric Chronometer of the Lick Observatory, by A. O. LEUSCHNER, of Berkeley.

c. Review of Miss CLERKE's "The System of the Stars," by GEORGE E. HALE, of Chicago.

d. Review of Dr. DREYER's "Life of TYCHO BRAHE," by TORVALD KÖHL, of Denmark.

e. The Period of the Rotation of the Sun near the Poles, as derived from the Coronas of 1878 and 1889, by Prof. F. H. BIGELOW, of Washington, D. C.

f. The Visibility of Interference-Fringes in the Focus of the Telescope, by Professor MICHELSON, of Worcester, Mass.

g. Observations of the Transit of *Mercury*, May 9th, 1891, by Messrs. BURCKHALTER, MOSES and PIERSON (Oakland and San Francisco); by Messrs. HOLDEN, BURNHAM, SCHAEBERLE, KEELER and BARNARD (Mt. Hamilton); by Professor SOULÉ (Berkeley); Professor GEORGE (San Jose); General IRISH (Reno, Nevada); Mr. PARMLEY (Ogden, Utah), and others.

Professor TREAT, of Napa College, was kind enough to read a paper by Professor PRITCHETT on the Photographs of the Total Solar Eclipse of January 1, 1889, taken by the party of the Washington University of St. Louis. An enlarged picture of this corona from Professor PRITCHETT's negatives was exhibited to the meeting. Professor HOLDEN explained to the Society the work which was being done by Professor WEINEK, of Prague, in enlarging the photographs of the Moon taken with the great telescope and in making drawings from them. (*See* a note by Professor WEINEK in the present number.) Adjourned.

MINUTES OF THE FIFTH AND SIXTH MEETINGS OF THE CHICAGO SECTION A. S. P., APRIL 7 AND MAY 5, 1891.

The *fifth* regular meeting of the Chicago Section of the A. S. P. was held Tuesday evening, April 7, 1891, at the Sherman House, Chicago.

Mr. DOUGLASS was in the chair. The minutes of the last meeting were accepted as read. As no business required attention, Prof. G. W. HOUGH gave an interesting lecture on "The Stellar Universe." The meeting then adjourned.

The *sixth* regular meeting of the Chicago Section of the A. S. P. was held Tuesday evening, May 5, 1891, at the Kenwood Physical Observatory, Chicago. After inspecting the instruments of the observatory and observing *Saturn* with the 12-inch equatorial, the members were called to order in the library by Chairman DOUGLASS. The minutes of the last meeting were accepted as read.

GEORGE E. HALE then gave an account of the methods used in solar observations, and described some spectroscopic phenomena recently observed and photographed at the Kenwood Observatory. The remarks were illustrated with an optical lantern. During the evening a photograph of the region around *Coma Berenices* was made with a camera strapped to the tube of the 12-inch equatorial, and provided with a short focus portrait lens.

Rev. H. O. HOFFMAN, Bloomington, Ill., has been added to the list of members of the Chicago Section, A. S. P. Adjourned.

GEORGE E. HALE, Secretary.

OFFICERS OF THE SOCIETY.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of one dollar to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery stamped with the seal of the Society. at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend any or all of the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific," at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

VOL. III. SAN FRANCISCO, CALIFORNIA, SEPTEMBER 5, 1891. NO. 17.

OBSERVATIONS OF *JUPITER* AND OF HIS SATELLITES WITH THE 36-INCH EQUATORIAL OF THE LICK OBSERVATORY (1888–1890).

During the years 1888–1890 the phenomena of *Jupiter's* satellites, etc., were observed with the large telescope in the intervals of other work by Messrs. HOLDEN, SCHAEBERLE, KEELER and CAMPBELL. (E. S. H.; J. M. S.; J. E. K.; W. W. C.) The following pages give the notes of such observations. The times are Pacific Standard Times (Greenwich mean times *minus* 8 hours). The numerous sketches made are here omitted.

The finished drawings made by Mr. KEELER in 1889 have been printed in *Publ.* A. S. P., vol. II, p. 15. The photographs of 1890 are referred to in these *Publications*, vol. III, p. 65 and in *Mon. Not.* R. A. S., vol. LI, p. 402 (article by A. STANLEY WILLIAMS, Esq.).

1888, June 9; *Occultation of 47 Libræ by Jupiter.*

P. s. t. of Immersion $14^h\ 13^m\ 50^s.2$, see *Astronomical Journal*, vol. VIII, p. 64, for details. The star was seen through the atmosphere of the planet for more than 80 seconds. E. S. H.

1888, June 22; *Eclipse (reappearance) of Satellite I.* Excellent vision, Wt. 5; eye-piece 670.

h. m. s.	
11 00 11.4;	reappearance, *faint*. This is not $0^s.5$ late.
11 00 32.1;	satellite twice as bright as at first.
11 00 54.1;	Mr. KEELER notes reappearance with 4-inch finder, power about 25.
11 01 37 ;	satellite full brightness?
11 02 06 ;	satellite full brightness?
11 02 31 ;	satellite full brightness?
11 02 54 ;	satellite is certainly of full brightness.

1888, June 22 (continued).

But looking at the satellite at 11^h 8^m I think the disc is fuller and the satellite even brighter than at 11^h 3^m. There was as much difference between the satellite when first seen (11^h 0^m) and its brightness at 11^h 3^m as between a star 14 mag. and one of 6 mag. That is 8 mags. E. S. H.

1888, July 20; *Transit of Shadow of Satellite III.*

Observations by J. M. S. and J. E. K.

h. m. s.

9 — —; the shadow is on the following limb, making a notch in the outline. It is oval in shape and twice as long as its indentation in the limb. Its longest dimension points north of *Jupiter's* centre. J. E. K. (Drawing omitted.)

9 2 38; a drawing by J. M. S. shows the longest dimension of the shadow to be 3 times the least dimension. The following end of the shadow just touches the east limb of *Jupiter*. On the north and south edges of the shadow is a faint penumbra half as wide as the smallest dimension of the shadow.

9 3 57; drawing by J. E. K. The shadow is now an oval with the longest axis about east and west, the shortest about north and south. The longest axis is about twice the lesser one. A penumbra at the *s. p.* end of the shadow is ¾ the area of the shadow. A penumbra at the *n. f.* end connects the shadow with the limb of *Jupiter* and is about the area of the shadow itself.

9 5 38; drawing by J. M. S. The shadow is oval with its longest axis about *s. p.* and *n. f.* and twice as great as its shortest dimension. The shadow is completely surrounded by a penumbra whose oval contour is similar to that of the shadow and whose axes are nearly those of the shadow itself.

9 22 —; drawing by J. M. S. The shadow is still oval as above and is surrounded by a penumbra as above.

9 40 —; drawing by J. M. S. A careful estimate by him shows the longest dimension of the shadow to point along a line making an angle 50° *preceding* the polar axis of the planet. The vertex of this angle is at the centre of the shadow which is 2½ diameters of the shadow from *Jupiter's* north limb.

h. m. s.
9 40 —; shadow on polar axis of the planet. J. M. S.
9 49 —; ditto. E. S. H.
Clouds till 10^h 34^m.
10 36 —; drawing by J. M. S. through haze. Shadow nearly at preceding limb of *Jupiter*. It is nearly 3 times as long as it is broad. It longest axis points about to *Jupiter's* south pole.
10 40 —; drawing by J. E. K. Shadow elongated: penumbra about it.
10 41 38; drawing by E. S. H. The line of elongation of the shadow which is now on *Jupiter's* limb intersects his polar axis prolonged one radius of the planet south of *Jupiter's* south limb. No penumbra seen.
10 47 38; shadow not quite off.
10 49 57; slight indentation visible. J. M. S.
10 50 27; shadow gone. J. M. S.

1888, July 23; *Transit of Shadow of Satellite I.*

J. E. K. observer.

The shadow appeared to be perfectly round during its transit; except that at times there was a slight elongation which seemed to be due to atmospheric vibration. A drawing shows a penumbra round the shadow when the latter was one of its own diameters from the preceding limb of the planet (just before egress). Seeing not good. J. E. K.

1888, July 24; *Transit of Red Spot.*

h. m.
Seeing very poor.
9 32.6; drawing made by J. M. S.
9 58.6; *centre* of red spot nearly to central meridian. E. S. H.
10 1.6; central now. E. S. H.
10 5.6; certainly past. E. S. H.
10 6.6; past. J. M. S.

On the south edge of the red spot is a decided [darker] shade [as drawn] with a white cloud south of it. Another similar cloud and shade are preceding and joined to those described, as if belonging to another red spot. The spot is all veiled over by a white film [as drawn at 10^h 28^m] and there is a central oval space whose longest diameter is ¾ of the major axis of the spot, and whose shortest is ⅓ of the minor axis. This oval space is whiter than the rest of the interior of the spot, which is of a pale red, veiled over as described.

h. m.
10 22.6 by watch; following edge of spot not yet central. J. M. S.
10 26.6 by watch; central now. J. M. S.
10 28.6 by watch; central now. E. S. H.

1888, July 29; *Transit of Red Spot* (J. M. S.).

8 41.3; transit of first limb.
9 33.3; transit of second limb.

1888, July 30; *Transit* (*Ingress*) *of Satellite I.*

h. m. s.
The seeing is very poor.
8 42 —; indentation [or flattening] of *Jupiter's* limb over 5° long.
8 43 —; the satellite is not diminished in brightness.
8 45 47; first contact, very uncertain.
8 47 —; there is a dark shade preceding the satellite.
8 48.3 ; dark shade as above; satellite bisected and seen as well inside as outside the limb.
8 50.1 ; satellite as before; no shade on preceding side of satellite but shades are both north and south of it.
8 51.1 ; satellite certainly inside the limb.
9 7 —; still seen.
9 14 —; still seen. E. S. H.

1888, July 31; *Transit of the Shadow of Satellite II.*

h. m.
7 44 ; drawings by E. S. H. The shadow is elongated 1¼ to 1. The longer axis intersects the polar axis of *Jupiter* prolonged to the north, north of the planet. Calling the angle whose vertex is at this point of intersection and whose sides are *Jupiter's* polar axis prolonged (north) and the major axis of the shadow, A; then A = 50°. There is a penumbra on the east and north edges of the shadow.
7 50 ; A = 30°. J. E. K.
7 52 ; shadow elongated so that its axis cuts *Jupiter's* polar axis, extended to the north, at a point 80″ north of *Jupiter's* centre.
7 52 ; a penumbra apparently surrounds the shadow. J. M. S.
7 57 ; A = 35° to 40°. E. S. H. The penumbra is not well seen.

h. m.
8 1 ; the shadow is best defined on the north and west sides. It has the same elongation as at 7^h 52^m. J. M. S.

8 0 ; drawing by J. E. K. The satellite sometimes appeared perfectly round, and sometimes elongated. The elongation as well as the penumbra he attributes to atmospheric vibration. A slight elongation in a direction parallel to the planet's limb, near egress, appeared to be real. J. E. K.

8 7.2; internal tangency of shadow and *Jupiter's* limb. J. E. K.

8 11.8; egress (last contact) of shadow. E. S. H.

8 21 ; satellite II appears to be elongated in the same direction as the shadow and as 1¼ to 1. The direction of elongation is parallel to the limb of *Jupiter* at 8^h 30^m. The eye-piece used is a single lens giving a power of 5400. Examining satellite III with the same lens it appears nearly round. The objective is in good adjustment. J. M. S. independently confirms the above.

1888, July 31; *Eclipse (reappearance) of Satellite I.*

Observer J. M. S.

h. m. s.
9 29 56 ; satellite first seen.

9 30 56 ; satellite a crescent.

9 31 56 ; satellite not half the disc illuminated yet. The shape is perfectly seen.

9 32 30 ; satellite half illuminated now.

9 33 20 ; satellite three-quarters illuminated now.

9 33 59 ; satellite nine-tenths illuminated now.

9 35 15.5; satellite fully illuminated now.

9 35 — ; satellites I and III, round and steady; satellite II, elongated up and down. Definition of II certainly not as good as on the others. J. M. S.

1888, August 10; *Transit of Red Spot.*

h. m. s. h. m.
8 45 — to 9 12; drawing by E. S. H.

8 40 42; preceding edge of spot on central meridian.

8 42 42; certainly past.

9 3 57; centre of spot is central on disc.

9 7 42; centre of spot very little past.

9 24 12; following edge central.

9 2 27; spot central from mean of limbs.

9 3 57; spot central by estimation. E. S. H.

1889, June 10; *Egress of Shadow of Satellite I.*

h. m. s.
12 43 +; the shadow is round.
12 53 13; first contact of shadow at egress. The shadow is elliptical with its major axis = 1½ minor axis.
12 56 8; last contact of shadow. E. S. H.

1889, June 10; *Transit (Egress) of Satellite I.*

The satellite is less than 5″ from the limb of *Jupiter*. It is a bright disc, and all around it is a dark shade which may be contrast.

h. m. s.
13 5 58; the satellite is slightly elongated in the direction of the major axis of *Jupiter*.
13 7 8; the satellite is elliptical; major axis = 1½ minor axis. Seeing pretty good.
13 10 41; internal tangency of limbs of satellite and planet; the former is still elongated.
13 11 25; first view of part of the satellite outside the planet's disc. E. S. H.

The part of the satellite which is on the disc of the planet has a shade around it, equal to its diameter in breadth.

h. m. s.
13 12 50; I is bisected.
13 15 10; I is round.
13 15 48; there is still a shade on the following side of the satellite.
13 16 20; external tangency.

The satellites examined with a high power and the discs of I, II, III, IV look round. III has some kind of marking on its disc, but the night is not good enough to say what form it has. E. S. H.

1889, June 18; *Occultation (reappearance) of Satellite I.*

h. m. s.
12 16 52; I, first seen on following limb; seeing poor, Wt. 2.
12 17 16; see half the satellite's disc through the planet's atmosphere.
12 19 2; whole disc seen, inside the planet's limb.
12 19 +; the planet's limb distorted.
12 20 20; egress. E. S. H.

1889, June 18; *Eclipse of Satellite III.*

h. m. s.
13 30 22; the satellite has a round disc, power 390, seeing Wt. 2.
13 42 52; the satellite appears to be flattened on the following side.
13 44 18; about half the disc of the satellite is obscured.
13 45 20; exactly half the disc is obscured as nearly as can be seen.
13 46 32; disc like a half moon.
13 53 9; disappeared.

A curious green patch on the middle belt of *Jupiter*. (See drawing of this date by J. E. K.) E. S. H.

1889, June 19; *Transit of Red Spot.*

h. m. s.
12 56 29; the preceding end of the red spot is barely past the centre of the disc. E. S. H.

1889, July 2; *Occultation of Satellite I.*

13 26 56; contact I,
13 29 25; bisection,
13 32 15; contact II,
} Wt. 2, seeing poor.

The satellite was seen inside the limb as a very brilliant stellar point and disappeared just at second contact. E. S. H.

1889, July 3; *Transit (Egress) of Satellite I and its Shadow.*

h. m. s.
12 30 —; the shadow is round, color brownish black. The satellite is brilliant; a little more so than the tops of some white clouds on the same reddish belt (north part of main belt).
12 36 22; satellite elongated east and west.
12 39 32; major axis of satellite = 1½ times minor axis, and inclined 5° to 10° to *Jupiter's* equator in direction *s. p.* and *n. f.*
12 40 22; the shadow *slightly* elongated in same direction.
12 42 7; major axis of satellite parallel to *Jupiter's* equator; shadow as before.
12 47 6; internal tangency of limbs of *Jupiter* and satellite I.
12 47 32; satellite is twice as long east and west as north and south.
12 48 38; first appearance of any part of the satellite outside the limb of *Jupiter*.
12 50 49; bisection of satellite.

h. m. s.
12 53 57; external tangency of satellite. The time from bisection to second contact is more than the time from first contact to bisection as it should be if the elongation of the satellite is only apparent and due to some action of *Jupiter's* atmosphere. The times are uncertain, however, owing to the poor seeing and low altitude.
12 55 14; free space between satellite and limb.
13 0 40; shadow *appears* of less diameter than at first.
13 2 49; first contact of shadow.
13 4 7; shadow bisected.
13 4 42; notch perfectly round; well seen.
13 6 15; shadow gone.

As may be seen by comparing the times of contacts and of bisections the observations are uncertain on account of poor seeing and low altitude. For the same reasons the apparent changes in the shapes of the satellite and shadow are doubtful from this night's observations. E. S. H.

1889, July 7; *Transit of Shadow of Satellite II; Transit of Shadow of Satellite IV.* Wt. = 3.

h. m. s.
9 56 57; shadow of IV makes a notch in the north limb equal to ¾ of the diameter of the shadow. Satellite IV looks circular.
10 2 17; the shadow is elongated; it major axis points slightly west of the centre of *Jupiter*. It is still a notch in the limb. It seems to have a penumbra about it.
10 3 —; the width of the penumbra is ¼ of the diameter of the satellite.
10 8 7; the shadow is a little east of the north end of *Jupiter's* axis.
10 9 27; still a notch; ¾ of its diameter inside the limb of the planet.
10 10 22; the shadow is on *Jupiter's* axis. The axis of the shadow points a little west of *Jupiter's* centre.
10 12 42; ingress of shadow of II first seen.
10 14 8; shadow of II half on. Shadow of IV elongated as at 10^h 10^m 22^s.
10 14 45; shadow of II all on.
10 16 38; shadow of IV as at 10^h 10^m 22^s.

h. m. s.
10 17 34; shadow of IV is at least twice as large as that of II. The centre of shadow of IV is much darker than the shadow of II. The shadow of II has a penumbra [drawing].

10 25 27; the disc of IV is certainly circular. I think there are markings on it, but the vision is not good enough to be certain.

10 34 —; the longest axis of shadow of IV now appears to be parallel to the axis of *Jupiter*.

10 39 —; the shadow of IV is about bisected; its longest axis seems to point east of *Jupiter's* centre.

10 50 57; the shadow of IV (projected on the olive-grey near north pole) has constantly been darker than the shadow of II (projected on a white belt just north of the red equatorial belt).

10 52 27; the shadow of IV still makes a rounded notch. Probably not more than ¼ of it is on the planet.

10 55 57; the shadow of IV is a faint undulation in the limb.

10 57 27; ditto.

10 58 57; ditto.

11 0 57; shadow of IV no longer visible.

11 59 —; II is quite bright; three of its own diameters from the limb.

12 6 18; internal contact of II.

12 9 12; satellite about bisected.

12 9 39; satellite bisected.

12 12 9; about last contact.

12 12 54; last contact of II. The disc of II is all outside and it seems not more than ½ the diameter of I.

12 14 —; II seems to increase in brightness all the time.

12 18 —; II seems at least twice as bright as when fairly clear of the limb. (Contrast? atmosphere of planet?) E. S. H.

Colors of the Satellites.

I is fiery yellow, E. S. H.; same as III, J. E. K.; redder than III, E. S. H.

III is strong yellow, E. S. H.; golden yellow, J. E. K.

IV is pale lemon yellow, E. S. H.; a pale yellowish white, J. E. K.

1889, July 11; *Transit of Red Spot.*

h. m. s.
11 32 9; red spot central.
11 37 —; red spot certainly past transit.

On this night (and on subsequent occasions) attempts were made to measure the distance apart of two objects on *Jupiter* (*a*) at or near the limb (*b*) at the centre, with the object of comparing the effect of *Jupiter's* atmosphere in the two cases. When the planet is higher, I think this can be done, but I have had no success during the present opposition. E. S. H.

1889, July 11; *Eclipse* (*reappearance*) *of Satellite II.*

h. m. s.
12 19 24; first glimpse of II.
12 23 15; satellite seems to be of full brightness. The disc is round.

The outline of the shadow of *Jupiter* is not seen on the disc of II. At $12^h\ 19^m\ 24^s$ the satellite was just barely visible—say 17 magnitude, and it gradually increased in brightness till $12^h\ 23^m$, and very likely even after that time. E. S. H.

1890, August 17. Dark markings on *Jupiter's* satellite III. The seeing was average. Eye-pieces 360 and 520 were employed. No markings were seen at any time on satellites I, II, IV. At $9^h\ 55^m$ P. s. t. a dark marking was seen by E. S. H. on III, extending from the centre to the *north* limb. The marking was all to the *east* of a *north* and *south* diameter. It was seen (and independently drawn) by W. W. C. exactly as by E. S. H., except that for W. W. C. it terminated before reaching the north limb. Its greatest dimension east and west was ¼ of the diameter of III. There is no doubt whatever regarding its existence. At $11^h\ 40^m$ P. s. t. both observers are certain that the marking is further *south* and further *east* on the disc. The shape of the marking not so well seen as before. If the spot is a part of the surface of III and turns with it, the rotation period of this satellite is short. E. S. H. and W. W. C.

THE OBSERVATORY OF THE U. S. MILITARY ACADEMY AT WEST POINT, N. Y.

Memorandum by Lieut. F. S. HARLOW, U. S. A. (in charge).

"The permanent observatory at the Military Academy is provided at present with a REPSOLD Meridian Circle, a CLARK Equatorial, and a BOND Chronograph used in connection with a HOWARD mean time and a HARDY sidereal clock.

"The circle is 26 inches in diameter, graduated to 2′, and reads directly to 1″ by means of four reading microscopes fitted with micrometers. Each micrometer screw carries two pairs of parallel wires.

"The telescope has a free aperture of 7 inches, a focal length of 81.5 inches, and is provided with five positive eye-pieces of powers 70, 150, 210, 280, and 350, together with two sun-glasses, and the R. A. and Declination micrometers. The reticle carries 23 transit wires. For use with the nadir basin a reflecting nadir cap is provided. The illumination of the several microscopes and of the main field is in accordance with the REPSOLD design.

"Two collimators are mounted on piers in the meridian. Free aperture, 3 inches. Focal length, 38 inches.

"The CLARK Equatorial has a free aperture of 12 inches, and a focal length of 15 feet. Powers of the negative eye-pieces, 150, 300, 600, and 1200. The declination circle is graduated to 10′, and is provided with two verniers read by micrometer microscopes directly to 10″. The hour circle is graduated to 1^m and reads by verniers to 1^s. These circles are all illuminated by small incandescent lamps in connection with a battery of 4 or 5 bichromate cells. The filar position micrometer has 3 positive eye-pieces of powers, 110, 155, and 210, and the wires are illuminated by electricity.

"The equatorial is also fitted with a 'telespectroscope,' in which two gratings are used, one on speculum metal by ROWLAND, with 14438 lines per inch, and one on glass by RUTHERFORD, with 17100 lines per inch.

"The electric connections of the BOND chronograph provide for switching either the mean time or sidereal clock, and either the meridian circle or sidereal clock, and either the meridian circle or equatorial, into circuit with itself.

"A building is now in process of construction in which we hope to have mounted within a few months, a 9⅝ inch equatorial for photograhic purposes, and a concave grating by ROWLAND, 6 inch, with camera complete.

"In the field observatory we have two transits, a zenith telescope, an altazimuth, and several STACKPOLE sextants."

MEASUREMENT OF *JUPITER'S* SATELLITES BY INTERFERENCE.

By A. A. MICHELSON.

It has long been known that even in a telescope which is theoretically perfect, the image of a luminous point is composed of a series of concentric circles with a bright patch of light at the common center. This system of circles can easily be observed by examining any bright star with a telescope provided with a circular diaphragm which diminishes the effective aperture. The appearance of the image is shown in Fig. 1. In the case of an object of finite angular magnitude the image could be constructed by drawing a system of such rings about every point in the geometrical image. The result for a small disc (corresponding to the appearance of one of the satellites of *Jupiter* as seen with a 12-inch telescope whose effective aperture has been reduced to six inches) is given in Fig. 2, the chief points of difference between this and Fig. 1 being the greater size of the bright central disc and the lesser clearness of the surrounding rings. The larger the disc the more nearly will the appearance of the image correspond to that of the object; and the smaller the object the more nearly does it correspond with Fig. 1, and the more difficult will be the measurement of its actual size. Thus, in the case just cited, the actual angular diameter is about one second of arc, and the uncertainty may amount to half this value or even more.

The relative uncertainty, other things being equal, will be less in proportion to the increase in the aperture, so that with the 36-inch telescope, the measurement of the diameters of *Jupiter's* satellites should be accurate to within ten per cent. under favorable conditions.

Fig. 1.

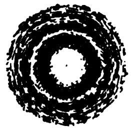


Fig. 2.

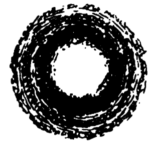
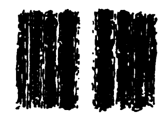


Fig. 3.



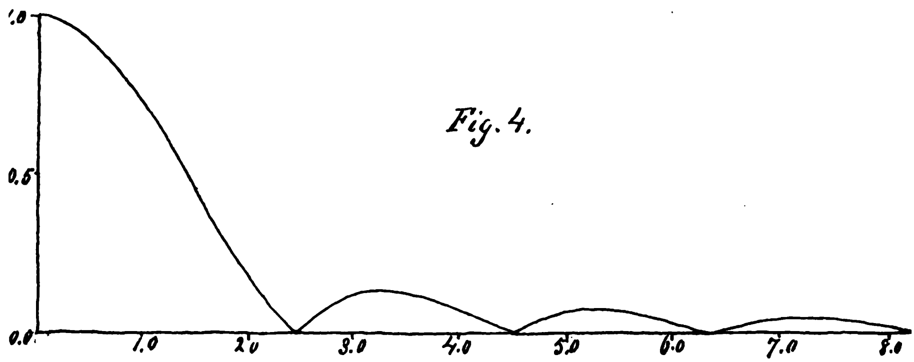


Fig. 4.

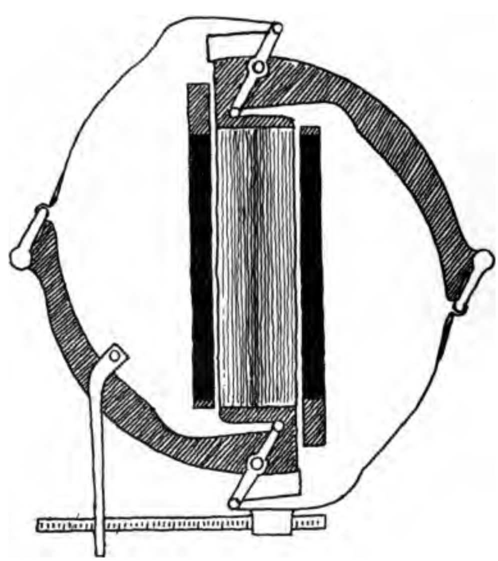


Fig. 5.

It is important to note that in all such measurements the image observed is a diffraction phenomenon—the rings being interference fringes and the settings being made on the position of that part of a fringe which is most easily identified. But such measurements must vary with the atmospheric conditions and especially with the observer—for no two observers will agree upon the exact part of the fringe to be measured, and the uncertainties are exaggerated when the fringes are disturbed by atmospheric tremors.

If, now, it be possible to find a relation between the size of the object and the *clearness* of the interference fringes, an independent method of measuring such minute objects will be furnished; and it is the purpose of this paper to show that such a method is not only feasible but in all probability gives results far more accurate than micrometric measurements of the image.

In a paper on the "Application of Interference Methods to Astronomical Measurements,"* an arrangement was described for producing such fringes, by providing the cap of the objective with two parallel slits, adjustable in width and distance apart. If such a combination be focused on a star, then, instead of the concentric rings before mentioned, there will be a series of straight equidistant bands whose length is parallel with the slits, the central one being brightest,† Fig. 3.

The general theory of these fringes may be found in the *Publications* A. S. P., vol. iii, no. 16, 1891. The general equation showing the relation between the *visibility* of the fringes and the distance between the slits is

$$V^2 = \frac{[\int \phi(x) \cos kx\, dx]^2 + [\int \phi(x) \sin kx\, dx]^2}{[\int \phi(x)\, dx]^2} \qquad (1)$$

which reduces to the simpler form

$$V = \frac{\int \phi(x) \cos kx\, dx}{\int \phi(x)\, dx} \qquad (2)$$

when the object viewed is symmetrical.

A number of applications of this formula are discussed in the former paper, but for the present purpose attention will be confined to the case in which the object viewed (or rather its projection) is a circular disc, uniformly illuminated.

* Philosophical Magazine, July, 1890.

† These will be superposed on another set of fringes due to diffraction from the edges of the slits; but the latter are too faint and broad to cause any confusion. Fig. 3 is in error, as the fringes should be in one group, and not in two.

In this case equation (2) becomes

$$V = \int_0^1 \sqrt{1 - \omega^2} \, . \cos \pi \frac{a}{a_0} \omega \, . \, d\omega \tag{3}$$

in which a is the angular diameter of the object, and a_0 is the smallest angle resolvable by an equivalent aperture; that is, the ratio of a light-wave to the distance between the slits.

The curve expressing this relation is given in Fig. 4, in which the ordinates are values of the visibility of the fringes and the abscissæ are the corresponding values of the a/a_0.

From this it will appear that the fringes disappear at recurring intervals, and in a laboratory experiment as many as four such disappearances were noted, and the average error in the resulting value of a, the angular magnitude of the disc, was found to be less than two per cent.

From the curve it is evident that the first disappearance is most readily and accurately observed, and for this we have

$$\text{whence putting } s\frac{a}{a_0} = 1.22;$$

for the distance between the centres of the slits, and taking for the wave-length of the brightest part of the spectrum 0.00055 mm.,* and dividing by the value of a second in radians we have

$$a = \frac{1.38}{s} \tag{4}$$

In consequence of the kind invitation extended by Professor HOLDEN it was decided to make a practical test of the usefulness of the proposed method at Mt. Hamilton.

For the preliminary experiments which are to be described it was thought desirable to use the 12-inch equatorial. Accordingly a cap, provided with two adjustable slits, was fitted over the objective and provided with a rod by means of which the distance between the slits could be altered gradually and at will by the observer, while the distance was measured on a millimeter scale attached to the sliding jaws. This arrangement which was constructed under the supervision of Mr. F. L. O. WADSWORTH, of Clark University, is shown in the accompanying diagram, Fig. 5.

With this apparatus the satellites of *Jupiter* were measured with results as given in the following table:

---

* The wave length will, of course, vary somewhat with the object observed but may be made constant by interposing a red glass.

TABLE I.

No. of Satellites.	I.	II.	III.	IV.	Seeing.
	"	"	"	"	
August 2......	1.29	1.19	1.88	1.68	Poor.
August 3......	1.29	....	1.59	1.68	Poor.
August 6......	1.30	1.21	1.69	1.56	Poor.
August 7......	1.30	1.18	1.77	1.71	Good.
Mean.......	1.29	1.19	1.73	1.66	

These are the values of the angular diameters of the satellites of *Jupiter* as seen from the earth. To reduce these to *Jupiter's* mean distance these values are to be multiplied by 0.79 which give for the final values

I.	II.	III.	IV.
1".02	0".94	1".37	1".31

For the sake of comparison these values are recorded in the following table together with those given by ENGELMANN, STRUVE and HOUGH, and the last column contains some results kindly furnished by Professor BURNHAM with the 36-inch on the same date (August 7th) as the last of the series by A. A. M.

TABLE II.

No. of Satellites.	A. A. M.	ENG.	ST.	HO.	BU.
I..............	1.02	1.08	1.02	1.11	1.11
II.............	0.94	0.91	0.91	0.98	1.00
III............	1.37	1.54	1.49	1.78	1.78
IV.............	1.31	1.28	1.27	1.46	1.61

It was found impossible to see the reappearance of the fringes on increasing the distance, yet the results of Table I show that the disappearance could still be sharply marked. Indeed the concordance of the observations made under different circumstances on different nights was even closer than was expected. With a larger telescope both the brightness of the fringes and their distance apart will be increased, and it may be confidently predicted that the accuracy will then be even greater.

The values given in the second column "ENGELMANN" are probably more reliable than the succeeding ones, but it is well worth noting that the differences between the results obtained by interference agree with the others quite as well as these agree with each other.

It should also be noted that the distance between the slits was about four inches. It may therefore be stated that for such measurements as have just been described, a telescope sufficiently large to admit a separation of four inches—say a six-inch—suitably provided with adjustable slits is fully equal to the largest telescopes now used without them.

It is hoped that within a few months the 36-inch equatorial will be supplied with a similar apparatus and observations begun for the definitive measurement of the satellites of *Jupiter* and *Saturn* and such of the asteroids as may come within the range of the instrument.

In concluding, I wish to take this opportunity in expressing my appreciation of the courtesy of Director HOLDEN in placing all the facilities of the Observatory at my disposal, and of the hearty co-operation of all the astronomers of the Observatory, especially the valuable assistance of Professor W. W. CAMPBELL in making the observations.

MT. HAMILTON.

STRASSBURG OBSERVATORY.

NOTICES FROM THE LICK OBSERVATORY.

PREPARED BY MEMBERS OF THE STAFF.

THE UNIVERSITY OBSERVATORY OF STRASSBURG.*

The accompanying cuts are copied from Lieut. WINTERHALTER'S Report on European Observatories, by the kind permission of the Superintendent of the U. S. Naval Observatory (*See* Publ. A. S. P., vol III, page 40). The short account here given is condensed from Lieut. WINTERHALTER'S report, and from other sources.

When the Germans took possession of Alsace, it was determined to create a University of the first class in the chief city of the province, and the installation and equipment of the new institution was on the most liberal scale. The most celebrated scholars of Germany were called to the University and were given *carte blanche* in the material provisions for the wants of their respective departments.

Dr. A. WINNECKE, then Vice-Director of the Imperial Observatory at Pulkowa, was made Professor of Astronomy in the University and Director of the new Observatory, and every detail of the buildings and instruments was left to him. The Observatory of Strassburg (begun in 1877) may be said to represent the matured ideas of European astronomers with regard to the construction and installation of instruments at the date in question, and it was designed and largely executed under the direct supervision of Prof. WINNECKE himself, who was universally acknowledged to have especial gifts in this, as in so many other directions.

I may be allowed to add that the designs for the Lick Observatory were being studied in the years 1874–1879, and that during a part of that time I had the great benefit of Professor WIN-

* Professor E. BECKER, Director.

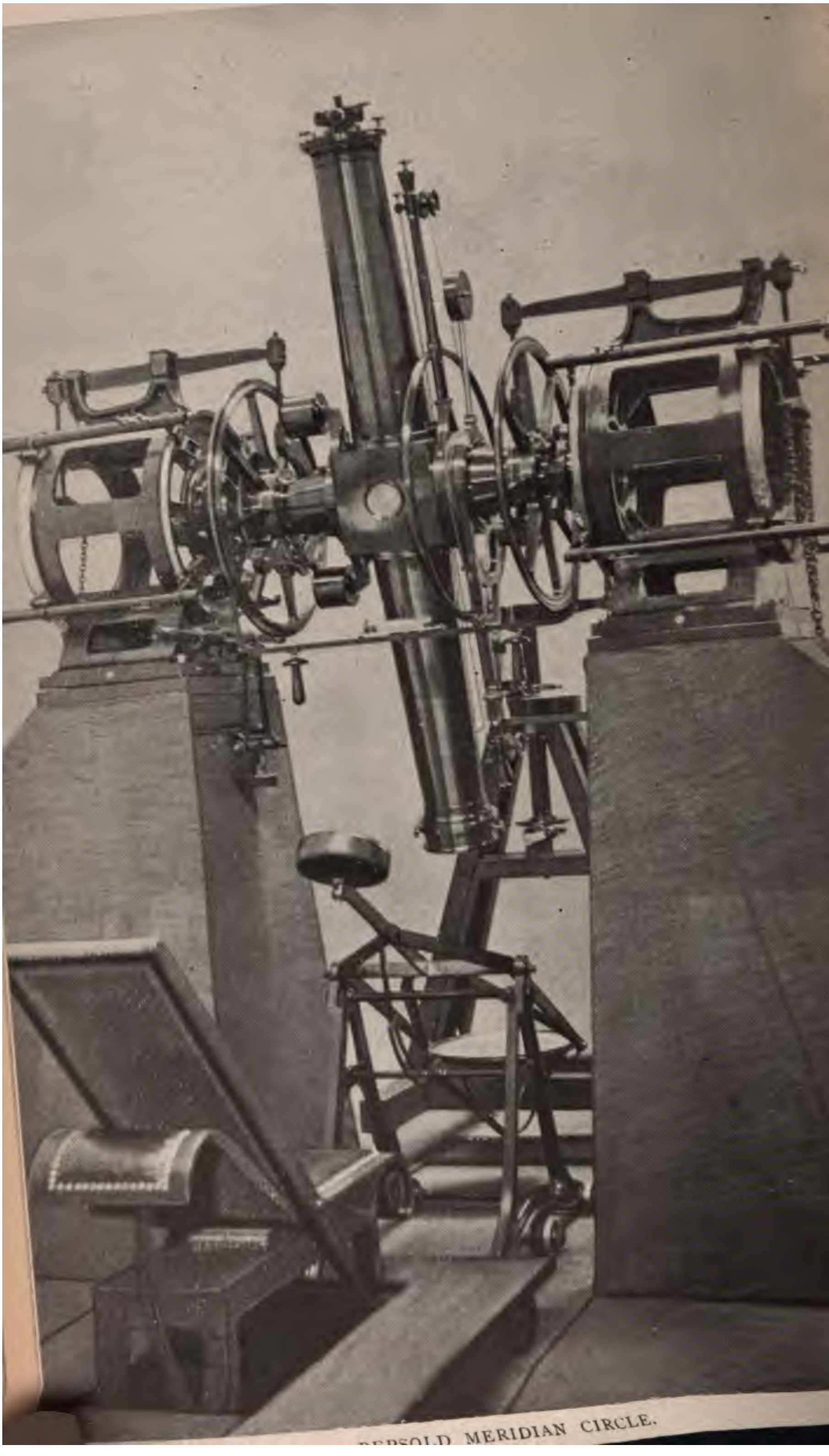
NECKE'S advice, and a current knowledge of the plans adopted by him at Strassburg. If the constructions at Mt. Hamilton differ in some important respects from those at Strassburg, it is partly on account of the very different conditions at the two places.

The Observatory is situated at the end of the Botanic Garden of the University, and is composed of two principal buildings, the great dome, and the meridian rooms, with the smaller domes (see the cut). These are connected by a covered way, and connected by another covered way (shown in the extreme left-hand side of the cut) with the observer's house.

The great equatorial is of 18 inches aperture, and was made by MERZ, the successor of FRAUENHOFER. It is one of the largest telescopes of Europe (Milan, 18 inches, Cambridge, England, 25 inches, Vienna, 27 inches, Nice, 30 inches, Pulkowa, 30 inches), and is said to be an excellent instrument. The great dome is 36 feet in diameter. Its shutter is so arranged as to open from horizon to horizon, which will not be a good plan wherever high winds prevail.

Lieut. WINTERHALTER says (page 222): "The dominating idea of the arrangements of mounting and of service of the instrument seems to have been a desire to make the observer independent of assistance, an idea not realized here, and scarcely liable to be elsewhere, in an equatorial of large size." I have quoted this remark in order that I may say that this idea is perfectly realized at the Lick Observatory with the 36-inch equatorial, thanks to Messrs. WARNER & SWASEY, the makers of the mounting. A great number of the observations of 1888 and 1889 with the great telescope have been made by observers working alone—by Mr. BURNHAM, MR. SCHAEBERLE, Mr. KEELER, Mr. BARNARD and myself. Mr. KEELER'S spectroscopic observations (which are far more complex than ordinary micrometric work) have, in great part, been made without assistance; and assistance is not indispensable, except for photographic work, though, of course, two observers will do far more work in a given time than one. I am far from saying that this is the most economical way to use a great equatorial, but our experience shows that it is perfectly practicable.

Other extra-meridian instruments at Strassburg are the heliometer, the orbit-sweeper (an equatorial which can be set so as to sweep along the path of a planet or of a comet), the alt-azimuth and the comet-seeker.



REPSOLD MERIDIAN CIRCLE.

The latter (made by Messrs. REPSOLD) is so intelligent in idea that a cut of it is reproduced here.

I do not know that the orbit-sweeper has been used otherwise than as a simple equatorial. An alt-azimuth instrument which would give results approaching in precision to those derived from the best meridian-circles would be eminently fitted to solve many of the fundamental problems of astronomy by new methods. With this end in view, Professor WINNECKE designed such an instrument, of 4-inch aperture, which was made by the REPSOLDS, and mounted in one of the smaller domes. In spite of the great care expended upon this instrument, it does not seem, so far, to have realized the expectations regarding it. It appears that for the finest work it is necessary to confine an instrument (and the observer) to a simple set of operations, as was carried out by W. STRUVE in planning the instruments and work for the Pulkowa Observatory. Even the meridian circle, which gives both right-ascension and zenith distance at the same transit of a star, was pronounced by STRUVE to be too complex, and was relegated to differential work; while all the absolute determinations at Pulkowa have been made by means of the two separate instruments—the transit for R. A., and the vertical circle for Z. D.

The meridian circle of the Strassburg Observatory was made by the REPSOLDS on the general plans suggested by Professor WINNECKE. (See the cut.)

The meridian circle of the Lick Observatory is almost an exact copy of that at Strassburg, and is certainly a magnificent example of workmanship and design. I think, however, that both Professor SCHAEBERLE and myself would advise, if we were called upon to suggest any changes in it, a return to the severe simplicity advocated by W. STRUVE rather than any change in the opposite direction.

The observations so far made by these two meridian circles indicate that they will produce, in competent hands, work of a very high class, and they have no superiors. Two more circles by the same makers, of the same design and of the same dimensions, exist, though they are not yet in operation; namely, those of the observatories of Bonn and of Brussels.

The arrangement of the piers and of the meridian rooms at Strassburg shows the greatest care in design and in execution, and some of Professor WINNECKE's ideas have been carried out at Mt. Hamilton.

A very complete portable transit instrument by the REPSOLDS is shown in the accompanying cut as an example of elegant design, although it is not one of the Strassburg instruments; and here, perhaps, is the best place to give a cut of the form of heliometer mounting now adopted by the REPSOLDS and in use at the Observatories of New Haven, Cape of Good Hope, Leipzig, etc., etc.

The Strassburg Observatory has, so far, printed its observations in the *Astronomische Nachrichten* and not in separate volumes.

E. S. H.

OBSERVATIONS OF THE SOLAR ECLIPSE OF JUNE 6, 1891, AT OGDEN, UTAH, BY W. C. PARMLEY.

OFFICE OF CITY ENGINEER AND BUILDING INSPECTOR, OGDEN, UTAH, June 28, 1891.

DEAR PROFESSOR HOLDEN: I intended to report the eclipse of June 6 sooner, but have been very busy with my city work.

I used a lat. of 41° 13′ 09″.4, and long. 7^h 27^m $53^s.95$, for a station of observation from the old observatory, of 6435 feet east, and 75 feet north (slightly different from the position used for the transit of *Mercury*).

Computed and observed time were for mountain time,

	Computed. A.M.	Observed. A.M.
Beginning,	6^d 7^h 18^m $10^s.5$	18^m 23^s
Ending,	6^d 8^h 56^m $53^s.1$	56^m $53\frac{3}{4}^s$

After the eclipse was farther on, I was satisfied I did not note the beginning soon enough, but for the ending I had good observations. There is also no personal bias in the noted times.

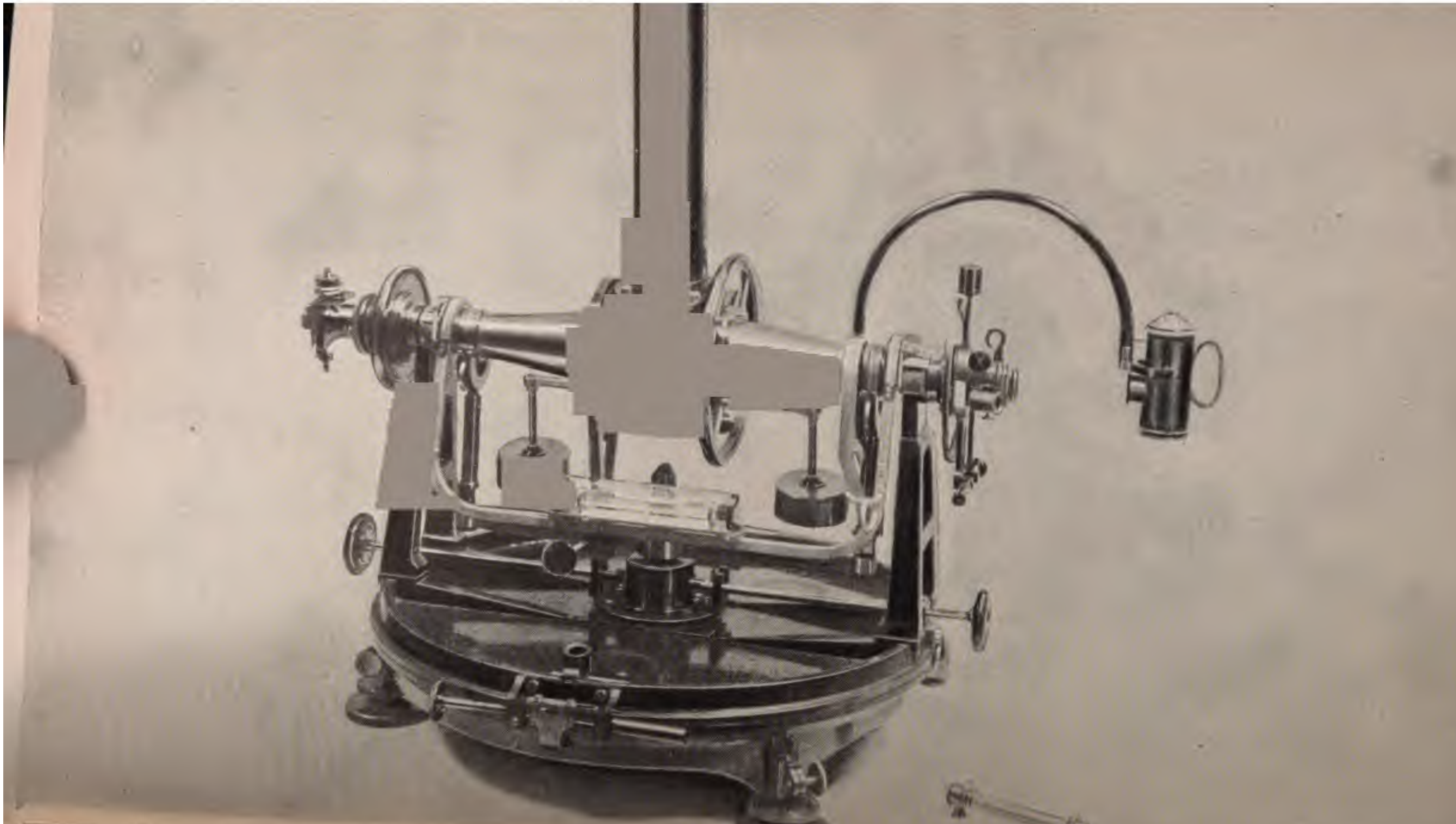
Yours very truly,

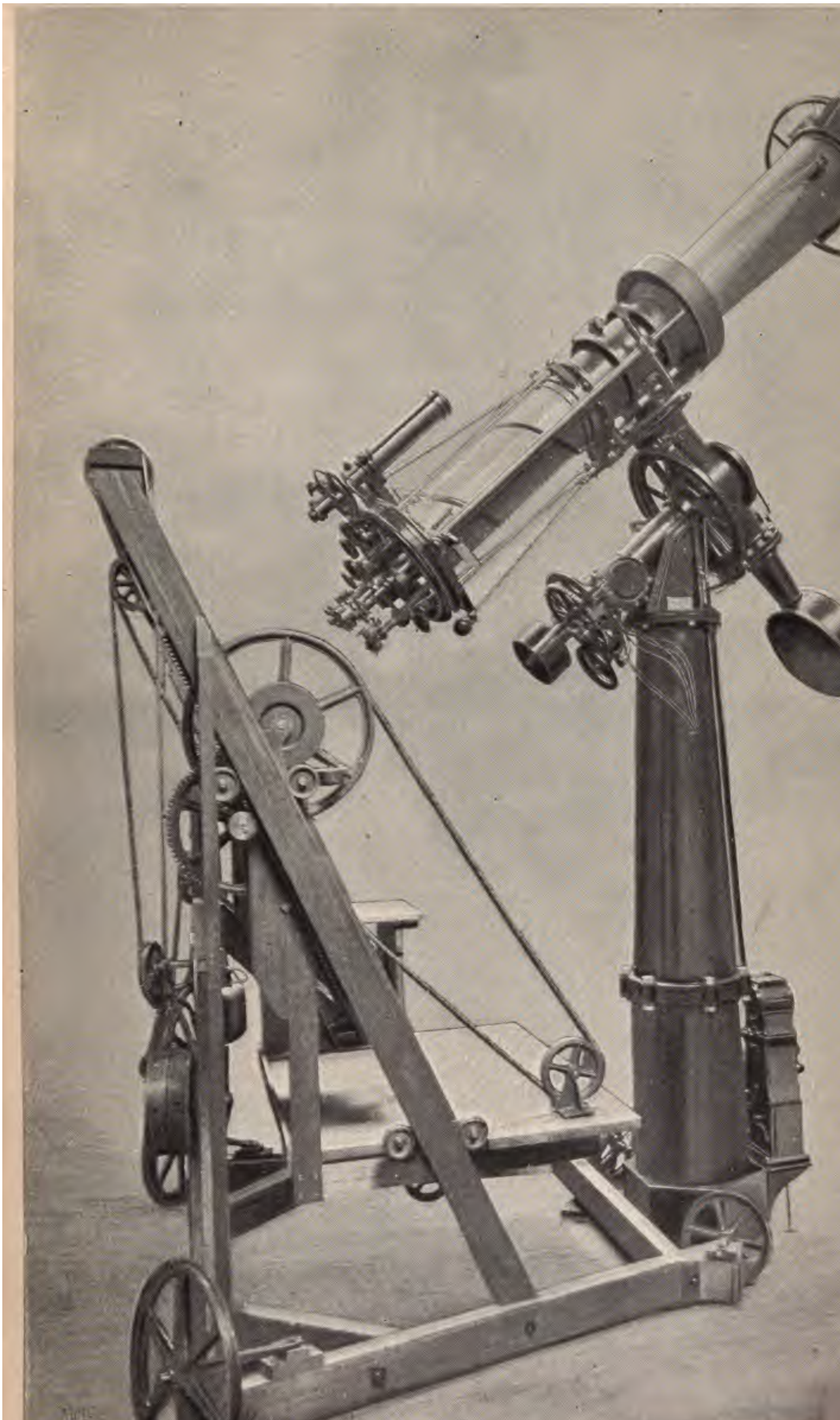
W. C. PARMLEY.

The telescope employed had an aperture of 1⅞ inches, and magnified 45 diameters.

SCIENTIFIC VISITORS TO THE LICK OBSERVATORY.

Professor MENDENHALL, Chief of the U. S. Coast and Geodetic Survey, with Mr. FRÉMONT MORSE of the Survey made a stay of several days at Mt. Hamilton, in early July, for the purpose of determining the force of gravity by the new (short-pendulum) apparatus, lately introduced into the practice of the survey.





REPSOLD HELIOMETER.

Special Students at Mt. Hamilton.

Professors C. W. Treat, of Napa College, California, and J. M. Taylor of the State University of Washington (Seattle), have spent a portion of the vacation at Mt. Hamilton in practice of astronomical observations and computations.

Appointment of Professor Kirkwood to the Stanford University.

Members of the Society will be glad to learn that Dr. Kirkwood, one of our honored members and contributors, has been appointed to deliver the lectures on astronomy at the Stanford University. Dr. Kirkwood is Professor Emeritus of mathematics and astronomy in the University of Indiana, and has resided for some years at Riverside, California. E. S. H.

Observations of the Planet *Uranus* with the 36-inch Equatorial, by Edward S. Holden, J. M. Schaeberle and James E. Keeler.

The following brief summary of observations which have been made at the Lick Observatory may be worth placing on record.

1889, Jan. 6.—E. S. H. and J. M. S. Bands on the planet were suspected by J. M. S.

During the spring of 1889 (January-April) *Uranus* was examined on every suitable occasion, usually by E. S. H. and J. E. K. The same is true of the spring of 1890, which was, however, unusually unfavorable.

1890, Feb. 1.—E. S. H. and J. E. K. Wt. 2. The planet seems to be circular in outline. Bands are suspected on the planet, perpendicular to the line joining *Uranus* and *Oberon* at $12^h\ 30^m$, sid. t. *p.* (est.) = 120°–125°, but this is very uncertain.

The planet was examined (among other dates) on 1890, Feb. 27 (E. S. H. and J. M. S); April 9 (E. S. H. and J. E. K.); April 13 (E. S. H. and J. M. S.). On April 13 bands were seen plainly on the disc, which were spoken of in *Publ.* A. S. P., vol. II, p. 197, and of which sketches are given in the plates which accompany the present paper. The general direction of these bands was estimated at 105° by J. M. S. and about 90° by E. S. H. They were very faint and uncertain, however. (See the figure herewith. It must be remembered that the bands in the figure are plain and definite markings, while the bands on the planet were always the faintest imaginable shades.)

In 1891, *Uranus* was examined as follows: April 20 (E. S. H. and J. M. S.); April 26 (E. S. H. and J. E. K.); April 27 (E. S. H. and J. M. S.); May 3 (E. S. H. and J. M. S.); May 4 (E. S. H. and J. M. S.); May 10 (E. S. H. and J. E. K.); May 24 (E. S. H., J. M. S. and J. E. K.); May 25 (E. S. H. and J. M. S.); June 4 (ditto); June 5 (ditto); June 7 (ditto); June 8 (ditto); June 9 (ditto); June 14 (ditto); June 15 (ditto); June 20 (J. M. S. and C. W. TREAT); June 22 (E. S. H. and J. M. S.).

On several occasions, bands were seen on the planet, which are shown in the accompanying drawings.

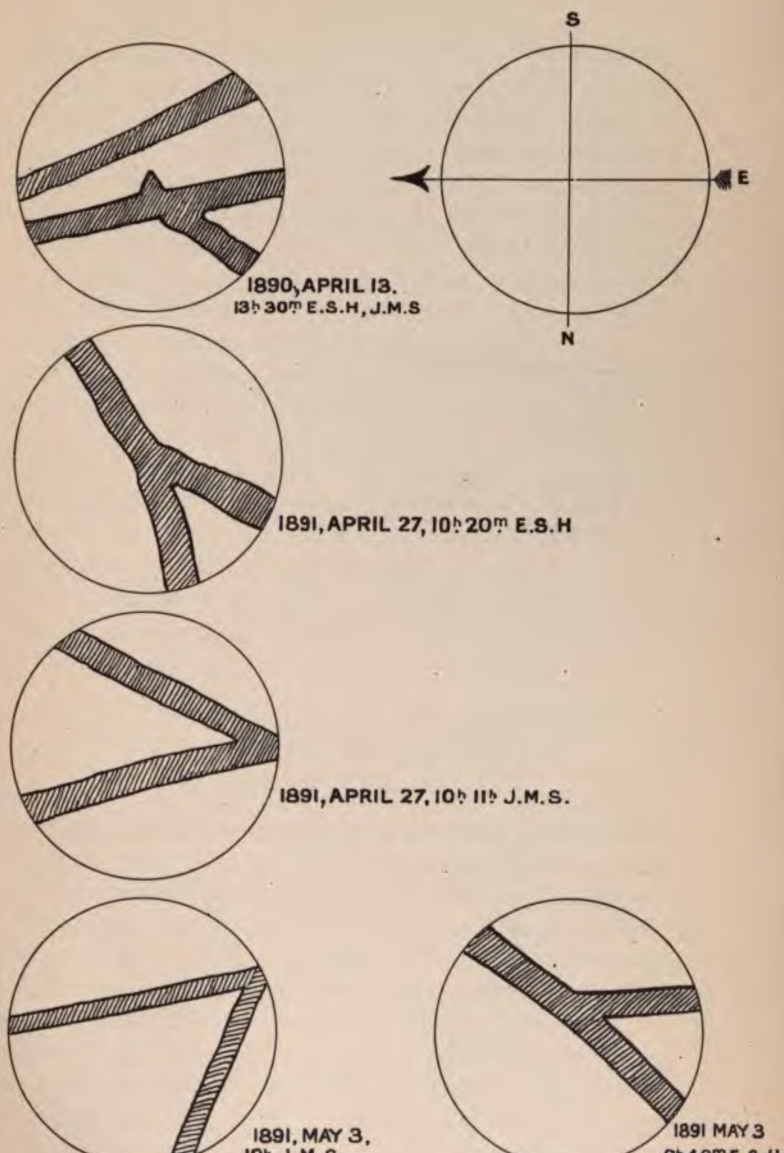
The bands were never well seen, as the circumstances were never entirely favorable. They were the merest shades on the planet's surface. On April 13, two observers (E. S. H. and J. M. S.) saw them essentially alike, except for a slight difference in the estimated position angle, and this night was the best, or one of the best, of the season. The lower marking of April 13 appears to have been seen by E. S. H. throughout. On the other hand, the later observations of J. M. S. are consistent with each other, but are, at first sight, quite inconsistent with the earlier ones, or even with the simultaneous observations of E. S. H. If, however, the drawings of the two observers are superposed, certain markings practically coincide, and thus seem to be confirmed. What is not common to the two drawings may be a pure mistake, or it may easily be that each observer saw only a part of the phenomenon. We are, on the whole, inclined to adopt the latter opinion, and, therefore, to publish these observations and figures in spite of their very unsatisfactory nature.

E. S. H., J. M. S., J. E. K.

HISTORY OF SCIENTIFIC SOCIETIES.

The *Report* of the Smithsonian Institution for 1889 contains (page 89 *et seq.*) an excellent article on The National Scientific Institutions at Berlin, the first part of which gives a very complete account of the Royal Academy of Sciences founded by LEIBNITZ in 1701. *Engineering* (May 22, 1891) commenced an admirable series of articles on London Societies, the first of which are devoted to the Royal Society (founded 1664–5). Other societies will be treated later. These accounts are very welcome and interesting.

E. S. H.



SKETCHES OF URANUS, 1890-1.

EXAMINATION OF *URANUS* FOR THE DETECTION OF NEW SATELLITES.

As the opposition of *Uranus* comes at a time of the year when our weather is most unfavorable, there have been very few occasions when the planet has been really well seen. Magnifying powers of 520 and 700 have generally been used, and very rarely 1000. In our best seeing, it would be advantageous to employ 1500 and even 2000. Under fairly good conditions, we have usually seen *Umbriel* and *Ariel* in all parts of their orbits. We are satisfied that no new satellite half as bright as *Ariel* at elongation exists within the orbit of *Umbriel*. It is not likely that any such object exists within the orbit of *Titania*.

When we come to the space beyond *Oberon* it is not possible to speak with certainty from our past observations. With an aperture as large as 36 inches, many small stars are visible in the field of view. If the atmosphere is steady and the circumstances are good, their places can be quickly determined. If, however, the conditions are unfavorable, as they ordinarily have been, it is often necessary to employ all the available time in making sure of the existence of some of the objects seen, and therefore it is possible that others have escaped notice. It is not practicable to be more definite in statement at present. E. S. H., J. M. S.

DISCOVERY OF A NEW CRATER ON THE MOON NEGATIVES OF THE LICK OBSERVATORY, BY PROFESSOR WEINEK OF PRAGUE.

[It is known that Professor WEINEK is making a careful study of the Moon negatives of the Lick Observatory, and is recording his results in drawings from the negatives which he enlarges 10-fold. See *Publ.* A. S. P. vol. III, page 253. He has already spent more than 200 hours of actual work on such drawings on 101 different days and has completed several drawings which it is hoped to publish shortly. Some 40–50 hours of work are required for a single crater. He has lately discovered a new crater on one of our negatives and at his request I give a brief description of its position, etc. I may add that a letter lately received from Professor WEINEK says that he has found that our best negatives (as for example that of August 31, 1890) require to be enlarged in the drawing *twenty-fold* in order to show all the features. This corresponds to a magnifying power of more than

1000 diameters in the telescope; or to put it in another way, the diameter of the full Moon on such a drawing would be more than nine feet. The results already obtained by Professor WEINEK completely justify the opinion of our Moon negatives which I expressed in the *Publications*, vol. II, p. 15. E. S. H.]

Extract from a letter of Professor Weinek.

K. K. STERNWARTE IN PRAG, 1891, May 23.

" * * * I send you to-day a rapid sketch of a part of the Moon southwest of *Pallas* and *Bode* (southeast of *Triesnecker*) copied from the negative of the Moon made at the Lick Observatory August 15, 1888. This shows east of A and B [SCHMIDT'S Map, section I] a crateriform object which is not laid down by either SCHMIDT, MAEDLER, LOHRMANN, or NEISON. * * * To explain my description of the position of the new object, I take as the origin of co-ordinates (O) the middle point of A B. The meridian through O lies, according to SCHMIDT, in the picture 7° to the left of B O, above, and 7° to the right of A O, below [north]. I call the position-angle (p) the angle from the north-end of the meridian counted towards the east. This angle together with the distance (d) determines the place of the new crater. [On my drawing, ten-fold enlarged, I find] $AB = 33.7$ *m m.*; $d = 8.5$ *m m.*; $p = 75°$; diameter $= 1.8$ *m m.*

"The question now is whether this is due to some imperfection of the plate. If it is a real object, the discovery is interesting, for SCHMIDT has drawn everything in this neighborhood as level. * * * If the object is real it has a different character from that of the two craters towards the south, because its shadow shows a greater extent. It cannot be funnel-shaped, but it must have a flat base and its west wall must be higher than the east one, and the west wall must decline gently towards the exterior. It may be called a crater-pit or round valley * * * ."

L. WEINEK.

[This discovery of Professor WEINEK'S was verified by me on the L. O. negatives of Aug. 24 and Nov. 3, 1890. The negative of Sept. 22, 1890, shows the region very well, and it is especially interesting as exhibiting an extensive system of *rills*, all of which are new, and some of which are formed of confluent craters. Professor WEINEK'S new crater lies at the intersection of two of these rills. A sketch of the neighborhood, showing the new crater and some of the rills was made from the L. O. negative of Sept. 22 and sent to Professor WEINEK on June 10. On June 15 I examined the region with the large telescope and sent Professor WEINEK a copy of my drawing. It shows the new crater as circular with an interior shadow. It seems to be situated in the exact centre of a raised mound (of its own lava?) On the edge of this mound is a companion crater also new. Other new features were seen and mapped, and they will be published in due time. E. S. H.]

APPOINTMENT OF DR. HENRY CREW AS ASTRONOMER IN THE LICK OBSERVATORY.

The Regents of the University of California elected Dr. HENRY CREW, Instructor of Physics in Haverford College, as Astronomer in the Lick Observatory at their regular meeting of July 14, 1891. E. S. H.

PERMANENT IMPROVEMENTS AT MOUNT HAMILTON.

Observatory for the Crocker Photographic Telescope: A new observatory has been built to cover the WILLARD photographic lens ($a = 5.9$ inches, $f = 31$ inches) and its mounting by BRASHEAR, which have been presented to the Lick Observatory by Hon. C. F. CROCKER. The dome is ten feet in diameter, and attached to it is a photographic dark room, etc., about ten feet by eleven feet. The building has been placed on the slope of the hill a few feet south of HUYGHENS reservoir. This equatorial mounting is stout enough to carry an eight-inch refractor.

New Store House and Wood Shed on the Summit: The proposed improvements to the surroundings of the tomb of JAMES LICK make it necessary to provide a store house to contain various tools and pieces of apparatus (the electric lighting engine presented to the Lick Observatory by the EDISON Manufacturing Company, among others), and accordingly the Regents of the University have set apart the sum of $1500 to provide for such a building, and for a wood shed, which is much needed. These buildings will be placed on the summit-plateau almost directly east of the 75-foot dome. E. S. H.

ERRATUM IN NEISON'S "MOON."

In the Map facing page 130 interchange the names *Autolychus* and *Aristillus.* E. S. H.

On the Determination of Stellar Magnitudes by means of Photography, by Dr. C. V. L. Charlier.

[The following extracts from a private letter to Professor HOLDEN are printed by permission of Dr. CHARLIER; and Professor SCHAEBERLE has added a brief commentary.]

*   *   *   *   *   *

You will allow me to express my opinion as to your discussion of the determination of photographic magnitudes in No. 5 of your *Publications* (Vol. I, page 112), and to add a few words regarding the memoir of Professor SCHAEBERLE on the same subject (Vol. I, page 51). Against the fine method of Mr. SCHAEBERLE for determining the magnitudes of stars by photography it seems to me that the following remarks must be made:

1) . . . . The formula ($d = \alpha + \beta \log D + \gamma . D . \log t$) that he employs to express the relation between the dimensions of the star discs, the time of exposure and the aperture of the objective, is not suitable for general application. In fact it must be remembered that for the most of the instruments hitherto examined the diameters of the star-discs seem to increase proportionally to a certain power of the time of exposure. Now in all these cases I think the formula of Mr. SCHAEBERLE cannot be applied. Take for instance the instrument which I have employed in Stockholm in my photometric researches, for which I found the law (2) $d = d_0 \sqrt[4]{t}$. If we seek to determine the constants f and g in the formula of Mr. SCHAEBERLE $d = f + g \log t$ so as to satisfy the observed values of the diameters of *Polaris* (page 7 in my memoir), we obtain

$$f \quad 21.6$$
$$g \quad 43.3$$

and the different computed values of d as compared with the observed ones are given in the following table, where I have written down also the values, which follow according to the formula (2).

SCHAEBERLE:	22,	35,	48,	61,	74,	87,	100,	112,	125,	139
OBSERVED:	34,	41,	45,	56,	60,	78,	89,	108,	131,	156
CHARLIER:	33,	39,	46,	55,	65,	78,	92,	110,	131,	156

You find from this comparison that (2) almost completely reproduces the observations while the formula of Mr. SCHAEBERLE shows a distinct and systematic difference.

It is very interesting that photographic instruments seem to belong, in general, to two different classes. For one class the formula of Mr. SCHAEBERLE is the most suitable—for instance for the photographic telescope employed in the Lick Observatory or in Potsdam—for the other, and it seems the greater number, the increase of the star-discs proceeds proportionally to a certain power of the time of exposure. Is the cause of this anomaly to be sought in the different qualities of the plates employed? Or does it depend upon the objective? It seems to me that the theory of the development of the image is closely connected with this phenomenon.

2.) The other remark that I would make on Mr. SCHAEBERLE'S method is as follows: The application of (1) for the determination of stellar magnitudes requires us to assume that the brightness of the image of a star in the focus of an objective is proportional to the free aperture of the objective. Now this assumption is somewhat uncertain. Almost all observers, who have made researches in stellar photometry, have shown, that this proportionality only exists within narrow limits. For the ZÖLLNER photometer of the Observatory in Upsala, for instance, I have obtained (*Astrophotometrische Studien*, page 11) a difference greater than half a magnitude in applying the law in question by diminishing the aperture to the fifth of its original value. The application of the method of Mr. SCHAEBERLE to this instrument would accordingly be allowable only when the difference in stellar magnitude is very small (in maximum 1.5 magnitudes). Now this may be peculiar to the instrument in question, and the circumstances may be different for the instrument of Mr. SCHAEBERLE and perhaps more favorable. But the main point is that the proportionality of the aperture of the objective and the brightness of the image is somewhat doubtful. The difficulty can only be removed by a special research on the relation between these two factors for the special instrument employed in such investigations.

Finally, I venture to say a few words regarding your own proposal to establish a system for determining photographic magnitudes.* It now seems to me that the method proposed by you is in principle the best possible. In the research which I made on the brightness of the *Pleiades*, the circumstances were more favorable than in the general problem. Most of the stars being of the same spectral type it was *a priori* probable that the ratio between the photographic brightness of the different stars

* See *Publ.* A. S. P. Vol. I. page 119.

would, in general, be the same as the corresponding ratio of the visual brightness. When the question is no longer to determine the brightness of such a group of stars, but to establish a system of magnitudes for stars all over the heavens, I think it, if not necessary, at least desirable to do this to a certain degree independently of all visual evaluations of the magnitude. I use the expression "to a certain degree," meaning that the light ratio employed in determining the system of photographic magnitudes ought to be the same as that employed in visual photometry. From this point of view, I think that a combination of the methods employed by Mr. SCHAEBERLE and by myself will perhaps be sufficient to establish an absolute system of photographic magnitudes. With the method of Mr. SCHAEBERLE, which of course is somewhat troublesome to use in extensive series of observations, a sufficient number of "standard stars" is first to be determined. The remaining stars will then be very easily determined by the formula which I have proposed, having fixed for each plate the values of the constants *a* and *b* with the aid of the above-named standard stars.

* * * * * *

C. V. L. CHARLIER.

OBSERVATORY OF UPSALA, April 6, 1891.

Note on the above Letter.

With reference to the above letter from Dr. CHARLIER, I desire to make a few remarks.

I entirely agree with Dr. CHARLIER that the comparison given above shows that the formula to be employed in the reduction of the photographs must be that one which is deduced from the results obtained with the particular instrument and plate employed in the photographic work.

In my paper, referred to by Dr. CHARLIER, I expressly stated that the final equation represented the observed diameters on a No. 26 SEED plate in the focus of the particular telescope used.

With reference to the statement "The application of (1) for the determination of stellar magnitudes requires us to assume that the brightness of the image in the focus of an objective is proportional to the free aperture of the objective," I wish to say that while the remarks made on page 57 of my paper would naturally lead to such a conclusion, still such is not necessarily the case as I shall now attempt to show.

In deducing the fundamental formula the factors for any particular case are so determined that an observed diameter representing a given magnitude is best represented for any one of the three following conditions:

(1) Constant aperture with varying time.
(2) Varying aperture with constant time.
(3) Both aperture and time varying.

In other words no assumption is made, the relation between time and aperture as expressed by the equation being such that each observed diameter represents the same magnitude for any given star. This same relation is then used to find the theoretical aperture which is required to produce a given brightness or magnitude, from the data obtained with a constant aperture; the resulting areas of the objective are not necessarily proportional to the corresponding resulting brightness. The area of the aperture is a function of the brightness in the stellar focus, but it is not necessarily a direct measure of the same.

In an extensive series of observations the work required to obtain the desired results will in the end be practically independent of the form of the original equation, since such results will naturally be taken directly from the tables, which, when once computed for a given instrument and plate, will require the same labor in using, whatever the form of the original equation may be.

From a note in the 1891 May No. of the *Monthly Notices of the Royal Astronomical Society*, it appears that several years ago Professor PRITCHARD obtained an expression for the diameter of the photographic image of a star, in which the logarithm of the time entered as a factor. I have not yet had an opportunity of seeing the original paper which is not in the library of the Lick Observatory.

With reference to Dr. CHARLIER'S remarks on the development of the plates, I can add that it appears from an investigation "On atmospheric absorption" now nearly completed, that the differences between two plates taken from the same box is sometimes so great that should the same constants be used in the reductions for the two plates, the resulting brightness of a given star on one plate would occasionally be as much as twice as great as on the other plate exposed under the same conditions. The necessity for having an impression of a standard star on each plate is, therefore, apparent.

It is safe to say that the law of variation in the diameter of the image of a star with varying times of exposure must be tested for each instrument used, since no two telescopes will ever have exactly the same form of focal image.

A uniformity in the kind of plate used is of course indispensible if a direct comparison is a desideratum.

J. M. SCHAEBERLE.

MT. HAMILTON, July 27, 1891.

ERRATA IN THE SECOND ARMAGH CATALOGUE OF STARS.

Communicated by Dr. J. L. E. DREYER, Director of the Armagh Observatory.

No. 178, *for* $10^s.61$ *read* $9^s.61$.

No. 770, *for* $9^s.88$ *read* $11^s.34$.

No. 1083, *for* $27^s.25$ *read* $28^s.25$.

No. 1102, *for* $32^s.62$ *read* $33^s.24$.

No. 1138, *dele* seconds of R. A., "Epoch" and "Obs." The star was not observed in R. A.

No. 1138, in N. P. D. *for* 48′ *read* 47′.

No. 1531, in N. P. D. *for* 6′ *read* 5′.

Page 152. No. 1055 is ARG. XXXIII, the P. M. is according to ARGELANDER $-0^s.0141$, $+0''.100$.

Page 158. First column, *for* 1035 *read* 1435.

FOREST FIRES AT MOUNT HAMILTON, JULY, 1891.

[The following report to the Regents of the University of California may have some interest to others as a part of the history of the Lick Observatory.]

MOUNT HAMILTON, July 29, 1891.

HON. T. G. PHELPS, *Chairman L. O. Committee:*

DEAR SIR,—I beg to submit the following report on the forest fires of July 21 to July 28. I have asked Professor SCHAEBERLE to write this, as he was in charge of the Observatory for most of the time—but he prefers that I should give you this account.

The Observatory is at the summit of a rocky peak called Mt. Hamilton. Just north of it is a deep wide thickly wooded cañon—*Cañon Negro*—and the mountain *Galileo* is on the other side of this cañon, about 4500 feet distant. The whole object was to keep the fire from reaching the chapparal in this cañon. It could enter in two ways; either by passing down the cañon north of *Galileo* (in which the *Joaquin Spring* is situated) and down the cañon of

Isabel Creek, thus beginning to burn from the bottom of *Cañon Negro;* or it could enter over the summits of the other mountain crests (*Copernicus*, *Galileo*, *Kepler*) which are above the cañon on its north and east sides.

If it *had* entered, it is probable that the greater part of the chapparal in *Cañon Negro* would have burned, and the cottages of Professor BARNARD, McDONALD and FRASER together with the Barn, Coast Survey House, Engine House, etc., would have been in the greatest danger.

I do not think the Lick Observatory was at any time in jeopardy. Perhaps it is worth while to put on record that one of the very first things done at the Lick Observatory, under the authority of the Regents, early in 1888, was to cut down the chapparal in the neighborhood of the cottages, a month having been spent in this work.

The first fire discovered was more than a mile east of the Observatory, beyond these crests, near the land of Mr. MORROW; and Tuesday (July 21), Wednesday (July 22) and Thursday (July 23) were spent in confining the fire to the slopes east of these crests. This was successfully accomplished by the astronomers and workmen of the Observatory, led by Professor SCHAEBERLE.

It was, however, only accomplished with extreme difficulty and by the severest personal exertions. Professor SCHAEBERLE, for example, was constantly at work for three days and two nights and he was seconded by our astronomers and workmen and by Professor TAYLOR, of the University of the State of Washington (a special student at the Lick Observatory).*

On Monday evening, July 20, two men stopped at the Smith Creek Hotel and then proceeded onwards toward the San Antonio Valley, along the county road leading east from Mt. Hamilton. The men passed WANDELL's ranche, about one mile north-east of the Observatory, some time about midnight of Monday, and it is believed that they made a camp somewhere between his place and that of Mr. ERKSON, and that the fire was accidently started by them.

About 7 A. M. of Tuesday, July 21, WANDELL discovered a brisk forest fire near him, and proceeded to put it out. Finding it more serious than he expected he sent word to the L. O. that

* Messrs. HOLDEN, BURNHAM and BARNARD were unfortunately absent from Mt. Hamilton, on official business, till Thursday, July 23.

he needed help, and the laborer (KING) was sent to assist. In the afternoon the fire increased and all the astronomers and workmen present at the Observatory went to aid in the work under the direction of Professor SCHAEBERLE.

The fire extended over the nearer parts of Mr. R. F. MORROW'S ranche and had entered on the L. O. Reservation by 2 A. M.

The fire increased during the night of Tuesday, and at 7 A. M. of Wednesday, July 22, it was near the high service reservoir (*Copernicus*) towards the east.

I returned to San José at 7 P. M. of July 22 and, learning of the fire, at once drove to Smith Creek, arriving at 11.20 P. M. After hearing from the Observatory by telephone I did not think it necessary to come to the Observatory that night, but I arrived early on the morning of Thursday, July 23. Messrs. BURNHAM and BARNARD arrived by the noon stage of that day, and at once went to the scene of the fire. It had not yet been possible to obtain men to aid in fighting the fire, although Prof. SCHAEBERLE had telephoned for them; and the astronomers of the L. O. with the workmen, continued their severe work. During the forenoon the fire was successfully beaten back from the crest of the slope joining *Copernicus* and *Hipparchus*. In the afternoon there was great danger that it would cross the crest running north from *Copernicus* towards *Newton*. This was prevented by cutting a trail some six feet broad from the reservoir northwards; the work being done by the astronomers and the L. O. workmen under Professor SCHAEBERLE'S direction. By very severe exertions the fire was stopped at this trail and thus was prevented from entering the cañon next to the L. O. and the beautiful grove on the northwest slope of *Copernicus* was saved.

On Thursday night the fire was kept north of MORROW'S old trail, and it filled the cañon east of *Newton* (the *Joaquin Spring* cañon) and burned over towards STEIGER'S ranche on the *Isabel Creek*. On Thursday evening laborers were obtained in San José and six men arrived at 4 A. M. Friday, and went to work at once —the astronomers leaving the work after three days and nights of nearly continuous labor.

On Friday night the fire was pretty well confined to the *Joaquin Spring* country and seemed to be under control. On Saturday morning a plowed road was made from the end of WANDELL'S wood road along the east flank of *Galileo*—across the saddle between *Galileo* and *Copernicus*—to keep the fire from entering our cañon from the north directly from the Joaquin. On Saturday noon all the extra workmen but one were sent back to San José. He was kept to cut chapparal and to watch the fire at night. We were aided by our neighbors Messrs. WANDELL, LUNDY and KINCAID with their workmen on Friday and Saturday. On Sunday morning an inspection by myself showed an increase of fire in the *Joaquin* cañon and a danger that the fire would work into *Cañon Negro* round the *Isabel Cañon* and the west ridge of *Galileo*. Accordingly I asked Mr. WANDELL to aid our own workmen, and all were set to work on Sunday noon. On Monday morning about 11 o'clock the fire was so severe that all the astronomers again turned out and after a most laborious and exciting day succeeded in restricting the fire to the cañon north of *Galileo* (the cañon of *Joaquin Spring*).

Assistance was again sent for and seven men arrived from Mr. KINCAID'S, and during the night seven or eight more men from BERNAL'S, and by Tuesday morning the fire was confined between the Isabel Creek on the north and spaces which had been burned over. Long trails were cut and back-fires set whenever necessary and at the present writing (July 29) it appears that the fire is entirely isolated. If it should enter the cañon just north of the Observatory (*Cañon Negro*) there is no way to stop it until it reaches the road to the Springs just below the wooden cottages. Accordingly this road is now being widened by felling the chapparal so as to protect the dwellings, the stables and our stock of hay and fuel.

The experience has been a novel one to all of us. Some idea of the force of the fire may be had by recalling the fact that all the chapparal on a steep hillside was completely burned up in 12 minutes; the area burned over being at least 240,000 square feet. At one time the astronomers were obliged to defend a crest something like a half a mile long, and to prevent the flames from crossing it while the fire was burning fiercely along the whole line. The flames rose 30, 40 or even 50 feet in the air, making a terrific heat, which had to be faced. If the fire is not stopped on the *farther* side of such a crest but is allowed to cross the ridge, the *hither* slope is sure to be fired by the pine cones which, once lighted, cannot be put out and which roll down the hither slope igniting everything they touch. Every leaf and tree is like tinder in the midst of our long summer and burns freely. No water was available for extinguishing this fire and dirt had to be shovelled on to the flames instead. The water in the reservoirs is necessary to our daily life; and moreover it had to be carefully saved in case of possible danger to the Observatory itself.

It would not be proper for me to close this account without a formal recognition of the really splendid service rendered to the Observatory by our astronomers and men. Every one on the Reservation was employed. Even the children made long trips carrying water and provisions; and the ladies with the servants saw to it that food was provided for those who were fighting the fire.

I beg leave to call your attention to the fact that experiences of this kind are not included in the lives of the members of the Faculties of the Universities of California. It is said that there were seven Professors of Sanskrit in the armies before Metz. I do not know how much they contributed to its fall, but I am sure that our astronomical corps has saved a vast deal of property to the University—including our pumping engine, all the buildings at the foot of the Observatory hill and many hundred acres of timbered land.

I am, dear Sir,

Very respectfully and truly yours,

EDWARD S. HOLDEN.

SCIENTIFIC VISITORS TO THE LICK OBSERVATORY.

We have lately had the pleasure of receiving at Mt. Hamilton Dr. DAVID STARR JORDAN, President of the Stanford University, in company with Professor GEORGE CHRYSTAL, F. R. S., who was making a flying visit to California.

Professor MICHELSON, of Clark University, Worcester, Massachusetts, is making a prolonged stay at the Observatory in order to try the experiments which are described in his paper in the present number of the *Publications*. E. S. H.

ATMOSPHERIC ABSORPTION OF THE PHOTOGRAPHIC RAYS.

In an investigation for determining the law of the atmospheric absorption of the photographic rays of light I have deduced the following empirical formula for expressing the brightness of a star at any zenith-distance in terms of the brightness which the star would have, theoretically, at the zenith-distance zero,

$$B = B_0 \left[1 - f . \tan\left(\left(\frac{z}{12}\right)^2\right) \right] .$$

In which B is the *observed* brightness corresponding to the zenith-distance z, expressed in degrees,

In which B_0 is the theoretical brightness corresponding to the zenith-distance zero,

In which f is a constant whose (mean) value is 0.6.

The quantity $\left(\frac{z}{12}\right)$ is to be considered as an abstract number, the square of which represents the number of degrees of which the trigonometrical tangent is required.

The observations were made on Mt. Hamilton by Prof. W. W. CAMPBELL in 1890, and by myself in 1889 and 1890. Those which I made in Cayenne are less reliable owing to the fact that the sky, during our stay of one month, was never wholly free from clouds. These clouds would form and disappear even while the exposures were being made. As it may be some time before the results in detail will be published, I have, at Professor HOLDEN'S request, written this preliminary note. J. M. SCHAEBERLE.

MT. HAMILTON, Aug. 24, 1891.

Minutes of the Meeting of the Board of Directors held at the Lick Observatory, Sept. 5th, 1891.

The President took the chair, and a quorum was present. The minutes of the last meeting were approved.

The following members were elected. An asterisk is added to the name of life-members duly elected. The membership of the Society is now 420, of whom 45 are life-members.

List of Members Elected Sept. 5th, 1891.

Robert Stanton Avery	320 A Street, Washington, D. C.
R. L. Bischoffsheim *	3, Rue Taitbout, Paris, France.
Dr. Charles M. Blake	1840 Howard Street, S. F., Cal.
Mrs. E. E. Cook	220 Main Street, Davenport, Iowa.
Alfred L. Edwards	12 W. 33d Street, New York City.
T. A. Hagerty	537 Belden Ave., Chicago, Ill.
John P. Hely, C. E.	418 Claremont Ave., Chicago, Ill.
David Hewes	2101 Van Ness Ave., S. F., Cal.
Mrs. Anna Lathrop Hewes	2101 Van Ness Ave., S. F., Cal.
Kirk Himrod	150 Lincoln Ave., Chicago, Ill.
William Hoskins	Lagrange, Cook Co., Ill.
Mrs. M. M. Johnson	Circleville, Piute Co., Utah.
Professor J. H. Kedzie	Evanston, Ill.
Wm. H. Knight	108 York St., Cincinnati, Ohio.
Frank McMullen	cor. Cal. & Battery Sts., S.F., Cal.
Professor Malcolm McNeill	Lake Forest, Ill.
Beverly K. Moore	56 Bedford Street, Boston, Mass.
Miss Pendleton	1522 Locust St., Philadelphia, Pa.
Mrs. William Gibbons Preston	The Berkeley, Boston, Mass.
J. Henry Turner*	U. S. C. & G. S., Woodville, Va.
Miss M. J. Turner	11 Faxon Ave., Quincy, Mass.
Professor J. M. Taylor	State University, Seattle, Wash.
J. M. Van Slyke	29 S. Pinckney St., Madison, Wis.
Frederick H. Whitworth	Seattle, Wash.
Miss Mary E. Wilson	328 Boulevard Terrace, Oakland, Cal.

The Treasurer presented his report which was received and filed.

A Committee of two—namely Messrs. Burckhalter and Campbell were, on motion, appointed by the President to report on the advisability of making a change in Article VIII of the By-Laws, and to propose such a change should they deem it necessary. Adjourned.

MINUTES OF THE MEETING OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC, HELD IN THE LIBRARY OF THE LICK OBSERVATORY, SEPT. 5TH, 1891, AT 7 P.M.

The President occupied the chair, and a quorum was present.

The minutes of the last meeting, as printed in the last number of the *Publications*, were approved. A list of presents received was read by the Secretary, and the thanks of the Society were voted to the givers. The Secretary announced to the Society the names of twenty-five new members duly elected this day.

The following papers were presented :—

a. "Measurement of Jupiter's Satellites by Interference Methods," by Professor MICHELSON, of Clark University, Massachusetts.

b. "Enlarged Drawings from the Moon-negatives of the Lick Observatory, by Professor WEINEK, Director of the Observatory of Prague.

c. "Catalogue of the Library of the Society," prepared by OTTO VON GELDERN.

d. "Observations of Jupiter and of his Satellites with the 36-inch Equatorial of the Lick Observatory (1888–1890) ".

e. "The Observatory of the United States Military Academy at West Point," by Lieut. HARLOW, in charge.

The President announced the receipt from Chicago of a report from the Committee on the World's Fair appointed at the March meeting informing the Society that they had requested the World's Fair Commissioners to appoint the Secretary of the Committee, Mr. GEORGE E. HALE, to take charge and have supervision of the Astronomical Exhibit of this Society at the Columbian Exposition, and that it was contemplated that the exhibit should consist of astronomical apparatus and instruments, photographs and other exhibits from all parts of the world.

The paper (*a*) was then read to the Society by Professor CAMPBELL and discussed by various members. A print on glass of the planet *Jupiter* from negatives made with the great telescope on August 19, 1891 (showing four phases of the ingress of Satellite III, the shadow of the satellite on the planet and the red spot, etc., etc.), was shown to the members as well as a paper print of the great forest fire near Mt. Hamilton August 26, 1891. Adjourned.

Minutes of the Seventh Regular Meeting of the Chicago Section A. S. P.

The *seventh* regular meeting of the Chicago Section was held June 15, 1891, at the Kenwood Physical Observatory. The occasion had been selected for the dedication of the Observatory, and a number of invited guests were present. Mr. G. A. Douglass presided, and after a few remarks. introduced Prof. C. A. Young, who had made the journey from Princeton in order to be present at the dedication. Prof. Young made a very interesting address, in which he referred to the great importance of spectroscopic investigations in astronomy, and spoke of the physical observatories at Potsdam and Meudon, and those in this country formerly directed by Dr. Rutherfurd and Dr. Draper. He described the recent photographic studies of prominences and their spectra made at the Kenwood Observatory, and pointed out their connection with his own observations made at Mount Sherman.

Other speeches were made by Prof. G. W. Hough of the Dearborn Observatory, Mr. J. A. Brashear of Allegheny, Mr. J. W. Scott of the *Chicago Herald*, President E. D. Eaton of Beloit College, Dr. H. H. Belfield of the Chicago Manual Training School, Prof. S. I. Curtiss, Rev. E. L. Williston, Rev. Dr. E. F. Williams and Rev. Frank Gates.

The following have been proposed for membership in the A. S. P. and Chicago Section:

William Hoskins, Lagrange, Cook County, Ill.
J. H. Kedzie, Evanston, Ill.
Prof. Malcolm McNeill, Lake Forest University, Lake Forest, Ill.

George E. Hale, *Secretary*.

Minutes of the Eighth Regular Meeting of the Chicago Section A. S. P.

Held on Tuesday evening, July 14, 1891, at Dearborn Observatory, Evanston, Ill., the chairman, Mr. Gayton A. Douglass, presiding.

The minutes of the last meeting were read and approved.

Mr. A. C. Behr called attention to doubts expressed by Dr. Klein, as to estimates of the mass of *Arcturus*, based on its parallax as given by Dr. Elkin.

Prof. Hough said in substance, that while, theoretically, stellar parallaxes as small as $\frac{1}{10}$ second might be detected and that the mean of a large number of observations would leave the probable error at a minimum, yet, practically, unavoidable personal error much exceeded that amount, and rendered the result uncertain by much more than $\frac{1}{10}$ second.

Mr. BEHR, Prof. HOUGH and Mr. DOUGLASS showed by lime-light a large number of excellent lantern-slides from lunar, solar and stellar photos and drawings—also a lantern-slide of the great Aztec calendar-stone—of which a brief description and account was given.

Applications for membership in the A. S. P. and the Chicago Section thereof, were received from

JOHN P. HELY, C. E., 418 Claremont Avenue.
T. A. HAGERTY, 537 Belden Avenue.
KIRK HIMROD, 150 Lincoln Avenue.

All of Chicago, Ill.

For the remainder of the evening Prof. HOUGH courteously gave the society members the use of the large telescope of the Observatory.

R. W. PIKE, *Acting Secretary.*

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of one dollar to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend any or all of the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific," at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

VOL. III. SAN FRANCISCO, CALIFORNIA, OCTOBER 1, 1891. No. 18.

CATALOGUE OF THE LIBRARY OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC AND OF THE ALEXANDER MONTGOMERY LIBRARY.

Prepared for the Library Committee by OTTO VON GELDERN.

The Library of the Astronomical Society of the Pacific is composed of two main parts. Mr. ALEXANDER MONTGOMERY, a member of the Society, gave the sum of $2500 in 1889 (*see Publ.* A. S. P. vol. I, p. 129) which was devoted to the purpose of founding a library to be known by his name. (*See Publ.* A. S. P. vol. II, pp. 33, 34, 198 and vol. III, pp. 149, 260). One thousand dollars of Mr. MONTGOMERY's gift has been devoted to the purchase of books (whose titles are distinguished by a special mark (ϕ) in the following catalogue) and the balance of the MONTGOMERY Fund has been invested and the interest will be spent in increasing the collection.

The second part of our library is mainly derived from the gifts of friends of the Society, from observatories, learned societies and individuals, both at home and abroad. To all such we return our grateful thanks.

The books are now kept in the rooms of the Society (819 Market Street, San Francisco) and they are available to all members under the following regulations. A resident member may obtain any book by presenting his library card. Two books only can be taken at any one time, for a period of two weeks. Members retaining books longer than the allotted time, will incur fines upon each book as follows: Longer than two weeks, ten cents per day. By renewal these can be retained as long again.

Any one defacing a book will be subject to fine and will be deprived of the use of the library.

A non-resident member, residing anywhere within the United States, may obtain books by sending his card with ten cents in postage stamps to the Secretary, who will return book and card. All risk of loss must be assumed by the member, and the book returned to the Society, postage prepaid.

Reference books cannot be taken from the library.

The following Catalogue has been compiled by Mr. OTTO von GELDERN and approved by the Library Committee (Messrs. MOLERA, v. GELDERN, GITCHELL) and is printed for the convenience of the members. Extra copies can be had on application to either of the Secretaries.

The Catalogue is divided into two parts: Part I relates only to bound books and Part II includes the unbound books and pamphlets.

The following abbreviations are employed:—S for 16mo; D for 12mo; O for 8vo; Q for 4to; F for folio and T for 24mo.

CATALOGUE OF THE LIBRARY.

PART I.—BOUND BOOKS.

ABBOT (T. W.): Elementary Theory of the Tides. ϕ, London, 1888; 1 vol., D, no. 292.

ABNEY (W. de W.): *See* SCHELLEN.

ABOUL-WEFA: Théorie de la lune. Paris, 1873; 1 vol., Q, no. 524.

AIRY (G. B.): Lectures, Popular Astronomy. ϕ, London, 1887; 12th edit., 1 vol., S, 2 copies, nos. 278–279.

ALFONSO X (King of Spain): Libros del saber de Astronomia. Por Don Manuel Rico y Sinobas. ϕ, Madrid, 1863–67; 5 vols., F^5, nos. 324–328, reference books.

ANDRÉ (C.) and G. Rayet: L'Astronomie pratique et les Observatoires en Europe et Amérique. ϕ, Paris; 5 vols., S, 1° p.—Angleterre, 1874; 2° p.—Ecosse, Irlande, etc., 1874; 3° p.—(par André et Angot) Etats Unis d'Amérique, 1877; 4° p.—(par André et Angot) Observatoires de L'Amérique du Sud, 1881; 5° p.—(par C. André, G. Rayet et A. Angot) Observatoires d' Italie, 1878. Nos. 161–165.

ANGOT (A.): *See* ANDRÉ.

ANTHONY (W.) and C. F. Brackett: Elementary Text Book of Physics. ϕ, New York, 1888; (5th edit., rev. and enl.) 1 vol., O, no. 52, reference book.

ARAGO (F.): Oeuvres complètes par J. A. BARRAL. *Astronomie populaire.* Paris; (2d edit.), 4 vols., O, nos. 153–156.

——: Analyse de la vie des travaux de Sir WM. HERSCHEL. ϕ, Paris, 1843; 1 vol., T, no. 185.

——: Rapport pour la réimpression des Oeuvres Mathématiques de La PLACE. ϕ, Paris, 1842; 1 vol., T, no. 187.

(The) ASTRONOMICAL REGISTER: Vols. 1–24. ϕ, London, 1863–1886; O, vols. 1–2, no. 420; vols. 3–7, nos. 421–425; vols. 8–9, no. 426; vols. 10–24, nos. 427–441.

BACH (M.): Calcul des Eclipses du Soleil par la méthode des projections. ϕ, (3 plates.) Paris, 1860; 1 vol., O, no. 191.

BACKHOUSE: *See* SUNDERLAND.

BAILY (F.): Account of the Rev. JOHN FLAMSTEED, to which is added his British Catalogue of Stars. ϕ, London, 1835; 1 vol., Q, no. 329.

BAILLY (J. S.): Histoire de l'Astronomie moderne. ϕ, (Plates,) Paris, 1779–82; 3 vols., sq. O, nos. 125–127.

——: Histoire de l'Astronomie indienne et Orientale. ϕ, Paris, 1787; 1 vol., sq. O, no. 124.

——: Histoire de l'Astronomie ancienne. ϕ, (3 plates.) Paris, 1781; (2d edit.) 1 vol., sq. O, no. 123.

BAKHUYZEN (Van de Sande): *See* LEIDEN.

BALL (R. S.): Astronomy. (Rev. by S. NEWCOMB.) ϕ, New York, 1878; 1 vol., S, no. 39.

BARRAL (J. A.): *See* ARAGO.

BIGELOW (F. H.): *See* WASHINGTON (Smithsonian Inst.).

BIOT (J. B.): *See* LE VERRIER.

——: Traité élémentaire d'Astronomie physique. ϕ, Paris, 1841–57; 5 vols., O, nos. 118–121, reference books.

——: Nouvelles études sur les refractions atmosphériques. ϕ, (n. t. p.,) 1 vol., Q, no. 262.

——: Recherches sur les Réfractions Extraordinaires qui ont lieu près de l'horizon. Paris, 1810; 1 vol., Q, no. 510.

BLAKE (J. F.): Astronomical Myths based on FLAMMARION'S History of the Heavens. ϕ, London, 1877; 1 vol., D, no. 295.

BOUCHET (U.): Hémérologie ou traité complet des Calendriers. ϕ, Paris, 1868; 1 vol., O, no. 167.

BRACKETT (C. F.): *See* ANTHONY.

BRETON (P.): Étude sur les orbites hyperboliques et sur l'existence probable d'une réfraction stellaire. ϕ, (3 plates.) Paris, 1880; 1 vol., O, no. 176.

BREWSTER (D.): Life of Sir ISAAC NEWTON. ϕ, (new and rev. edit. by W. T. Lynn,) London; 1 vol., D, no. 282.

——: Martyrs of Science. ϕ, London; 1 vol., D, no. 281.

——: More Worlds than One. ϕ, (illustr.) London, 1888; 1 vol., D, 2 copies, nos. 276–277.

BRINKLEY (J.): Astronomy, revised and partly rewritten with additional chapters by J. W. STUBBS and FRANCIS BRÜNNOW, with appendix of questions for examination. ϕ, (3d enl. edit.) London, 1886; 1 vol., D, no. 283.

BROWN (A. D.): *See* WASHINGTON (Reports).

BROWN (R.): Law of the Cosmic Order. ϕ, London, 1882; 1 vol., O, no. 290.

BRÜNNOW (Dr. F.): Spherical Astronomy. ϕ, (Translated by the author from the 2d German edit.) Berlin-London, 1865; 1 vol., O, no. 321.

——: *See* BRINKLEY.

BURR (E. F.): Ecce Coelum or Parish Astronomy, in six lectures. ϕ, (20th edit.) New York, 1867; 1 vol., D, no. 20.

BURRITT (E. H.): Geography of the Heavens. ϕ, (new edit. by H. MATTISON.) New York, 1873; 1 vol., D, 4 copies, nos. 25–28.

——: Atlas to illustrate his Geography of the Heavens (9 maps). ϕ, New York, 1856; 1 vol., F^5, 4 copies, nos. 128–131; no. 128 is a reference book.

CAREY (G. C.): Astronomy as it is known at the present day. ϕ, London, 1836; 1 vol., O, no. 299.

CARPENTER (J.): *See* NASMYTH.

CHALMERS (T.): Discourses on the Christian Revelation viewed in connection with Modern Astronomy. ϕ, 4th edit. Edinburgh, 1885; 1 vol., D, no 286.

CHAMBERS (Geo.): *See* SMYTH.

CHAMBERS (G. F.): Handbook of Descriptive and Practical Astronomy. ϕ, (4th edit.) Oxford, 1889–90; 3 vols., O. Vol. 1: The Sun; 2 copies, nos. 169–310. Vol. 2: Instruments, etc., no. 170. Vol. 3: Starry Heavens, 2 copies, nos. 171–313.

CHAPIN (F. H.): Mountaineering in Colorado. The Peaks about Estes Park. Boston, 1889; 1 vol., D, no. 525.

CHAUVENET (W.): Manual of Spherical and Practical Astronomy. Philadelphia, 1863; 1 vol., O, no. 241.

——: The same work, 5th edit. Philadelphia, 1889; 2 vols., O. Vol. 1: Spherical Astronomy, no. 82. Vol. 2: Theory and Use of Instruments, no. 83.

CHRISTIE (J. R.): Introduction to the Elements of Practical Astronomy. London, 1853; 1 vol., O, 2 copies, nos. 297–298.

CHRISTIE (W. H. M.): Astronomy (Manual of Elementary Science). φ, London, 1884; 1 vol., S, no. 288.

——: *See* The (Observatory).

CLARK (L.), and H. SADLER: Star Guide. London, 1886; 1 vol., O, no. 242.

——: Manual of the Transit Instrument as used for correct Time. φ, London, 1884; 1 vol., S, no. 304.

CLERKE (A. M.): Popular History of Astronomy during the XIX century. φ, (12th edit.) Edinburgh, 1887; 1 vol., 2 copies, nos. 314–315.

——: System of the Stars. φ, London, 1890; 1 vol., O, no. 491.

COSTARD (G.): History of Astronomy. φ, London, 1767; 1 vol., Q, no. 294.

CROVA (M. A.): Mesure de l' intensité calorifique des radiations solaires. φ, Paris, 1876; 1 vol., sq. Q, no. 179.

DELAMBRE (J. B. J.): Histoire de l'astronomie ancienne. φ, (17 plates.) Paris, 1817; 2 vols., sq. Q, nos. 116–117, reference books.

——: Histoire de l'astronomie du moyen age. φ, (27 plates.) Paris, 1819; 1 vol., Sq. Q, no. 115, reference book.

——: Histoire de l'astronomie au dix-huitienne Siècle. φ, Paris, 1827; 1 vol., Q, no. 149, reference book.

——: Astronomie théorique et pratique. φ, (plates.) Paris, 1814; 3 vols., Q, nos. 141–143, reference books.

DELAUNAY (C.): Cours élémentaire d' astronomie. φ, 7th edit., rev. par. ALBERT LEVY. (3 plates.) Paris, 1885; 1 vol., D, no. 182.

DRAYSON (A. W.): Common sights in the Heavens. φ, London, 1862; 1 vol., S, no. 300.

DUBOIS (E.): Passages des Vénus sur le disque solaire, 1874. φ, Paris, 1873; 1 vol., D, no. 184.

DUNKIN (E.): The Midnight Sky. φ, (new and rev. edit., 32 maps.) London, 1879; 1 vol., Q, 2 copies, nos. 263–264.

EDINBURGH (Royal Observatory): *Astronomical Observations*, 1878–1886. Edinburgh, 1886; 1 vol., sq. Q, no. 200, reference book.

EWING (T.): System of Geography. ϕ, (19th rev. edit.) Edinburgh, 1859; 1 vol., D, no. 40.

FALB (R.): *See Sirius.*

FAYE (H.): Cours d' astronomie. Paris, 1881–3; 2 vols., O, nos. 239–240.

——:L' Origine du monde. ϕ, (2d edit.) Paris, 1885, 1 vol,, O, no. 158.

FINDLATER (A.): Astronomy—(Chambers' Elementary Science Manuals.) ϕ, London and Edinburgh, 1884; 1 vol., D, no. 287.

FLAMMARION (C.): Etudes et lectures sur l' astronomie. ϕ, Paris, 1867–80; 9 vols., S, nos. 132–140.

——: Etoiles et les curiosités due ciel. ϕ, (illustrated.) Paris, 1890; 1 vol., Q, no. 148.

——: Astronomie populaire. ϕ, (illustrated, 6 plates.) Paris, 1890; 1 vol., Q, 2 copies, nos. 147 and 218.

——: Catalogue des etoiles doubles et multiples. ϕ, Paris, 1878; 1 vol., O, no. 166.

——: Atlas Céleste. ϕ, (8th edit.) Paris, 1887; 1 vol., F^6, no. 160, reference book.

——: *See* BLAKE.

FRANCOEUR (L. B.): Uranographie; ou, Traité élémentaire d' astronomie. ϕ, (6th edit., 8 plates.) Paris, 1853; 1 vol., O, no. 159.

GAZAN (A.): Constitution physique du Soleil. ϕ, Antibes, 1873; 1 vol., O, no. 193.

GILBERT (P.): Preuves mécanique de la rotation de la terre. ϕ, Paris, 1883; 1 vol., O, no. 177.

GILLISS (J. M.): *See* WASHINGTON (Smithsonian Inst.)

GINOT-DESROIS (Mlle.): Déscription et usages du calendrier astronomique et perpétuel. ϕ, Paris, 1861; 1 vol., O, no. 188.

GLAISHER (J.) *See* GUILLEMIN.

GRANT (R.): *See* JOHNSTON.

GREENWICH (Royal Observatory): New seven year catalogue of 2760 stars, reduced to Epoch, 1864. (Appendix 2d to Greenwich Observations, 1868.) ϕ, ——, 1 vol., F, no. 93.

——: Ten year catalogue, 1877–1866. London, 1889; 1 vol., F, no. 174, reference book.

GREENWICH (Royal Observatory): Astronomical, Magnetical and Meteorological Observations. London, 1889–1890; 1887, 1 vol., F, no. 173, reference book, 1887, Appendix 3 to Greenwich observations, 1 vol., F, no. 175, reference book. 1888. 1 vol., F, no. 503.

GUILLEMIN (A.): World of Comets. φ, (transl. and ed. by J. GLAISHER, illustr.) London, 1887; 1 vol., Q, no. 293.

——: The Heavens. φ, (ed. by J. N. LOCKYER and rev. by R. A. PROCTOR, 9th edit.) London, 1883; 1 vol., O, 2 copies, nos. 265–266.

HALL (A.): Orbits of *Oberon* and *Titania*, the outer satellites of *Uranus*. Washington, 1885; 1 vol., Q, no. 107.

HARKNESS (W.): Solar parallax and its related constants, including the figure and density of the earth. φ, Washington, 1891; 1 vol., Q, no. 508.

HARLEY (T.): Moon Lore. φ, London, 1885; 1 vol., O, no. 268.

HAUGHTON (S.): Manual of Tides and Tidal Currents. φ, (4th edit.) London, 1870; 1 vol., S, no. 289.

HERSCHEL (J. F. W.) Outlines of Astronomy. φ, (new edit., plates.) London, 1887; 1 vol., O, 2 copies, nos. 53–54. No. 54 is a reference book.

HIMMEL UND ERDE: Illustr. publication of the Gesellschaft URANIA, Berlin. (Ed. by Dr. M. W. MEYER.) Vol. I, Berlin, 1889; 1 vol., Q, no. 80.

HIND (J. R.): The Comets, with an account of modern discoveries. φ, London, 1852; 1 vol., D, no. 296.

——: Introduction to Astronomy. φ, (3d edit. rev. and enl.) London, 1863; 1 vol., D, no. 284.

——: The Comets of 1336. φ, London, 1857; 1 vol., D, no. 303.

HIRN (G. A.): Conservation de l' energie solaire. φ, Paris, 1883; 1 vol., sq. Q, no. 180.

——: Mémoire sur les conditions d' équilibre et sur la nature probable des anneaux de Saturne. φ, Paris, 1872; 1 vol., sq. Q, no. 181.

——: Mémoire sur les propriétés optiques de la flamme des corps en combustion. φ, Paris, 1 vol., O, no. 189.

HOLDEN (E. S.): A subject-index to the Publications of the U. S. Naval Observatory, 1845–1875. Washington, 1879; 1 vol., Q, no. 105.

HOLDEN (E. S.): Monograph of the Central Parts of the Nebula of Orion. Washington, 1882; 1 vol., Q, no. 106.

——: *See* Washington (National Academy, etc).

——: *See* Lick Observatory.

HOOGEWERFF (J. A.): Magnetic Observations of the U. S. Naval Observatory, 1888 and 1889. Washington, 1890; 1 vol., Q, no. 506.

HOUZEAU (J. C.); Vade-mecum de l' astronome. φ, Bruxelles. 1882; 1 vol., O, no. 417.

—— and LANCASTER: Bibliographie générale de l' astronomie. φ, Bruxelles, 1882–83, 3 vols., Q, nos. 144–146. No. 146 is reference book.

——: *See* LANCASTER.

HUMBOLDT (A. von): Cosmos. (Transl. by OTTÉ.) φ, London, 1886; 5 vols., D, nos. 271–275.

JEANS (H. W.): Hand-book of the Stars. φ, (4th edit. rev. by W. R. MARTIN, 3 plates.) London, 1888; 1 vol., Q, no. 267.

JEANS (G.): Practical Astronomy for the Unlearned. φ, London, 1856; 1 vol., D, no. 331.

JOHNSON (S. J.): Eclipses Past and Future. φ, (2d edit. with supplement.) London, 1889; 1 vol., S, no. 302.

JOHNSTON (A. K.): School Atlas of Astronomy, with an Elementary Survey of the Heavens, by R. GRANT. φ, new and enl. edit. illustr.) Edinburgh and London, 1886; 1 vol., Q, 4 copies, nos. 86–89. No. 88 is reference book.

KAISER (F.): *See* LEIDEN.

KANSAS ACADEMY OF SCIENCES: Transactions of the 22d meeting, 1889. Vol. 12, Part 1, Topeka, 1890; O, no. 519.

KASAN (Observatory): Observations des étoiles de la zone entre 75° et 80° de déclinaison boréale, sous la direction de MARION KOWALSKI, 1869–77, 1878–89; Kasan, 1885–87; 2 vols., Q, nos. 98–99.

KEDZIE (J. H.): Solar Heat, Gravitation and Sun-Spots. Chicago, 1886; 1 vol., D, no. 257.

KIRKWOOD (D.): Asteroids or Minor Planets between *Mars* and *Jupiter*. Philadelphia, 1888; 1 vol., D, 3 copies, nos. (44–45 φ) 254.

——: Meteoric Astronomy. φ, Philadelphia, 1867; 1 vol., D, no. 51.

KIRKWOOD (D.): Comets and Meteors. Philadelphia, 1873; 1 vol., no. 255.

KLEIN (H. J.): Anleitung zur Durchmusterung des Himmels. Astronomische Objecte. φ, Braunschweig, 1882; 1 vol., O, no. 244.

——: *See* SIRIUS.

KOWALSKI (M.): *See* KASAN (Observatory).

LALANDE (J.): Tafeln der fünfstelligen Logarithmen. (3d edit.) Leipzig, 1876; 1 vol., T, no. 259, reference book.

LANCASTER (A.): Notes Biographiques sur J. C. HOUZEAU. Bruxelles, 1889; 1 vol., Q, no. 111.

——: *See* HOUZEAU.

LANGLEY (S. P.): The New Astronomy. φ, (Illustr.) Boston, 1889; 1 vol., O, 2 copies, nos. 84–85, reference books.

——: *See* WASHINGTON (Reports).

LAPLACE (P. S. de): Histoire de l'Astronomie. φ, (2d edit.) Paris, 1865; 1 vol., no. 168.

——: Traité de Mécanique céleste. Paris, 1798–1825; 5 vols., sq. O, nos. 213–217.

——: Exposition du systéme du monde. (6th edit.) Paris, 1835; 1 vol., Q, no. 212, reference book.

LA PLATA (Observatory): Anuario, 1887. Buenos Aires, 1886; 1 vol., S, no. 96.

LEDGER (E.): The Sun, its Planets, etc. Lectures in Gresham College. London, 1882; 1 vol., D, 2 copies, nos. 257–(322 φ).

LEIDEN (Observatory): Annalen der Sternwarte in Leiden, vol. 3, F. KAISER. (7 plates.) Haag, 1872; Q, no. 221, reference book.

——: Vol. 4; H. G. van de SANDE BAKHUYZEN. Haag, 1875; Q, no. 222, reference book.

LEIPZIG (Astronomische Gesellschaft): *Vierteljahrsschrift.* (24th year.) Leipzig, 1889; 1 vol., O, no. 114.

LE VERRIER (J.): Memoires; also Memoires par M. BIOT. Paris, 1839–40; 3 vols., O, no. 513.

LEVY (A.): *See* DELAUNAY.

LEWIS (G. C.): Historical Survey of the Astronomy of the Ancients. φ, London, 1862; 1 vol., O, no. 330.

LICK (Observatory): Reports on the Observations of the Total Eclipse of the Sun. Jan. 1, 1889. Sacramento, 1889, 1 vol., O, no. 250, reference book.

——: Publications—1887. Prepared by E. S. HOLDEN. Sacramento, 1887; vol. I, Q, no. 208 reference book.

LOCKYER (J. N.): Studies in Spectrum Analysis. ϕ, (plates.) New York, 1878; 1 vol., D, no. 50.

——: Star-gazing Past and Present. ϕ, London, 1878; 1 vol., O, 4 copies, nos. 306–309.

——: Movements of the Earth. London, 1887; 1 vol., D, —

——: Meteoritic Hypothesis. ϕ, London, 1890; 1 vol., O, no. 490.

——: *See* GUILLEMIN.

LONDON (Royal Astronomical Society: Monthly Notices, 1827–29. London; 49 vols., D; vols. 1–29, nos. 242–470; Index, no. 471; vols. 30–46, nos. 472–488; vols. 47–49, nos. 530–532.

——: Memoirs. Herschel's Catalogue of Double Stars. ϕ, London, 1874; 1 vol., Q, no. 91.

LONG (R.): Astronomy in 5 books. ϕ, Cambridge, 1742; 1 vol., O, no. 79 reference book.

LOOMIS (E.): Treatise on Astronomy. ϕ, New York, 1889; 1 vol., O, no. 65.

——: Treatise on Meteorology. ϕ, New York, 1890; 1 vol., O, no. 261.

——: Elements of Astronomy for Academies, etc. ϕ, New York, 1889; 1 vol., D, 3 copies, nos. 66–68; no. 67 is reference book.

——: Introduction to Practical Astronomy. (7th edit.) New York, 1889; 1 vol., O, 3 copies, nos. 62–64; no. 63 is reference book.

LYNN (W. T.): Celestial Motions. ϕ, (6th rev. edit., 3 plates.) London, 1889; 1 vol., S, no. 301.

MADISON (Washburn Observatory): *Publications*, 1881–86. Madison, 1882–87; 5 vol., 2 copies of each, O. Vol. 1, nos. 245 and 514; vol. 2, nos. 246 and 515; vol. 3, nos. 247 and 516; vol. 4, nos. 248 and 517; vol. 5, nos. 249 and 518. Nos. 245–249 are reference books.

MADRID (Observatory): Observaciones Meteorologicas, 1884–89. Madrid, 1889–90; 6 vols., O; 1884, no. 237; 1885, no. 236; 1886, no. 319; 1886–87, no. 238; 1887, Resumen, no. 526; 1888–89, no. 320. Nos. 236, 237, 238 and 526 are reference books.

MAILLY (E.): Précis de l' histoire de l' Astronomie. (2d edit.) Paris, 1863; 1 vol., O, no. 168.

MARTIN (W. R.): *See* JEANS (H. W.)

MATTISON (H.): *See* BURRITT.

MAUNDER (E. W.): *See* (The) OBSERVATORY.

MEYER (Dr. M. W.): See *Himmel und Erde.*

MILLER (W.): Heavenly Bodies, their nature, etc. ϕ, London, 1883; 1 vol., D, no. 280.

MILLER (K. R.): Romance of Astronomy. ϕ, (3d edit.) London, 1882; 1 vol., D, no. 285.

MITCHEL (O. M.): Planetary and Stellar Worlds. ϕ, New York, 1874; 1 vol., D, 4 copies, nos. 12–15. No. 15 is reference book.

——: Popular Astronomy. ϕ, New York, 1876; 1 vol., D, 4 copies, nos. 21–24. No. 24 is reference book.

MOIGNO (Abbé): Vie du Père Secchi. ϕ, Paris, 1879; 1 vol., D, no. 183.

MUELLER (H.): Die Kepler'schen Gesetze. ϕ, Braunschweig. 1870; 1 vol., O, no. 252.

NASMYTH (J.) and JOHN CARPENTER: The Moon as a Planet, a World, etc. ϕ, (26 plates.) London, 1885; 1 vol., O, no. 56, reference book.

NEISON (E.): The Moon and the Conditions and Configuration of its Surface. ϕ, (Illustr., maps and plates.) London, 1876; 1 vol., O, no. 55, reference book.

NEWCOMB (S.): Uranian and Neptunian Systems investigated with the 26-inch Equatorial of the U. S. Naval Observatory. Washington, 1875; 1 vol., Q, no. 104.

——: Popular Astronomy. ϕ, (School edit., illustr., 5 maps.) New York, 1889; 1 vol., D, 5 copies, nos, 57–61; no. 57 is reference book.

——: Motion of the Moon. Washington, 1878; 1 vol., Q, no. 110.

——: *See* BALL.

——: *See* WASHINGTON (Reports).

NOBLE (W.): Hours with a 3-inch Telescope. φ, (Illustr., Maps of the Moon.) London, 1867; 1 vol., D, 5 copies, nos. 34–38.

NORMAND (J. A.): Memoire sur les occultations d'étoiles par les planètes. φ, Paris, 1876; 1 vol., sq. O, no. 178.

(The) OBSERVATORY: A monthly Review of Astronomy, ed. by W. H. M. CHRISTIE and E. W. MAUNDER, 1877–78. φ, London, 1878; 11 vols., O, nos. 492–502, reference books.

OLIVER (J. A. W. and others): Astronomy for Amateurs. φ, (Illustr.) London, 1888; 1 vol., D, 4 copies, nos. 16–19; no. 19 is a reference book.

OLMSTED (D.): Introduction to Astronomy. φ, rev. by E. S. SNELL. (3d stereo. edit.) New York, 1870; 1 vol., O, no. 69.

OXFORD (Radcliffe Observatory): Results of Astronomical and Meteorological Observations, 1886, under the Superintendence of EDWARD JAMES STONE. Oxford, 1890; 1 vol. (44th), Q, no. 512.

PALERMO (Observatory): *Pubblicazioni* (1884–1888). Palermo, 1889; 1 vol. (4th ed.), Q, no. 109.

PAGE (W. M.): New Light from old Eclipses, with an Introduction by Rev. JAMES H. BROOKS. φ, St. Louis, 1890; 1 vol., D, no. 172.

PARIS (Academy of Sciences): *Histoire* de l'Academie Royale des Sciences, avec les Memoires de Mathématique et de Physique. φ, (from the year 1699 to 1754, 2d rev., cor. and enl. edit.) Amsterdam, 1734–1763; 84 books, S, no. 333, 1699; no. 334, 1700; no. 335, 1701; no. 336, 1702; no. 337, 1703; no. 338, 1704; no. 339, 1705; no. 340, 1706; no. 341, 1707; no. 342, 1707; no. 343, 1708; no. 344, 1709; no. 345, 1710; no. 346, 1710; no. 347, 1711; no. 348, 1712; no. 349, 1713; no. 350, 1714; no. 351, 1715; no. 352, 1716; no. 353, 1717; no. 354, 1718; no. 355, 1718; no. 356, 1719; no. 357, 1720; no. 358, 1721; no. 359, 1722; no. 360, 1723; no. 361, 1724; no. 362, 1725; no. 363, 1726; no. 364, 1727; no. 365, 1728; no. 366, 1729; no. 367, 1730; no. 368, 1730; no. 369, 1731; no. 370, 1731; no. 371, 1731; no. 372, 1732; no. 373, 1732; no. 374, 1733; no. 375, 1733; no. 376, 1734; no. 377, 1734.

PARIS (Academy of Sciences): Continued.

Index to above (1699–1734), 3 vols.; S, nos. 378–380; no. 381, 1735; no. 382, 1736; no. 383, 1737; no. 384–385, 1739; no. 386–387, 1740; no. 388, 1741; no. 389, 1738; no. 390, 1742; no. 391, 1743; no. 392, 1744; no. 393, 1745; no. 394, 1746; no. 395, 1746; no. 396, 1746; no. 397, 1747; no. 398, 1747; no. 399, 1747; no. 400, 1748; no. 401, 1748; no. 402, 1748; no. 403, 1749; no. 404, 1750; no. 405, 1751; no. 406, Abregé, dernier vol. de la centurie premier—jusqu'a l'année 1751; no. 407—Index 1735–1751, vol. 4.

Nouvelle Centurie. No. 408, 1752; no. 409, 1752; no. 410, 1752; no. 411, 1753; no. 412, 1753; no. 413, 1753; no. 414, 1754; no. 415, 1754; no. 416, 1754.

PARIS (Bureau des Longitudes): Annuaire pour l'an, 1889. Paris, 1889; 1 vol., T, no. 94.

——: *Connaissance des Temps*, pour l'an, 1890. Paris, 1888; 1 vol., O, no. 97, reference book.

PARKES (S. H.): Unfinished Worlds. *p*, (2d edit.) London, 1888; 1 vol., O, no. 270.

PETIT (M. F.): Traité d'Astronomie. Paris, 1866; 2 vols., D, (no. 523, tome 1 and 2.)

PORRO (I.): Perfectionnement pratique des appareils optiques pour l'astronomie et pour la photographie. *p*, Paris, 1858; 1 vol., O, no. 190.

POTSDAM (Astrophysikalisches Observatorium): *Publicationen.* Vols. 4 and 6. Potsdam, 1889; Q, nos. 194–195; reference books.

PRAGUE (Observatory): Astronomische Beobachtungen (containing original drawings of the moon), by L. WEINEK, 1884–87. Prague, 1886–90; 2 vols., F_1, nos. 418–419.

PRESTEL (M. A. F.): Astronomisches Diagramm. Braunschweig, 1859; 1 vol., O, no. 253.

PROCTOR (R. A.): Star Atlas for Students. *p*, (12 maps, 5th edit.) London, 1886; 1 vol., F^4, no. 92, reference book.

——: Myths and Marvels of Astronomy. *p*, London, 1889, 1 vol., D, no. 489.

——: Orbs around us. *p*, (4th edit.) London, 1886; 1 vol., D, no. 49.

——: The Moon. *p*, (3d edit., 2 lunar photos.) London, 1886; 1 vol., D, no. 48.

PROCTOR (R. A.): Other Worlds than Ours. ϕ, New York, 1889; 1 vol., D, 3 copies, nos. 1, 2, 3; no. 1 is reference book.

——: Half-hours with the Telescope. ϕ, (10th edit. illustr.) New York, 1889; 1 vol., S, 3 copies, nos. 41–43; no. 43 is reference book.

——: *See* GUILLEMIN.

RADAU (M. R.): Progrès recents de l'astronomie stellaire. ϕ, Paris, 1876; 1 vol., S, no. 186.

RAYET (G.): *See* ANDRÉ.

RICO Y SINOBAS (Don Manuel): *See* ALFONSO.

RITTER (E.): Mémoire sur la détermination des éléments de l'orbite d'une comète ou d'une planète. Genéve, 1851; 1 vol., Q, no. 511.

SADLER (H.): *See* CLARK.

SAN FRANCISCO (Astronomical Society of the Pacific): *Publications*, 1889–90. San Francisco, 1889–90; O, vol. 1, no. —; vol. 2, nos. 521–522.

SAN FRANCISCO (Technical Society of the Pacific Coast): *Transactions*, 1884–88. San Francisco, 1884–88; 5 vols., O, no. 243. From May, 1889 to February, 1890, 1 vol., O, no. 112; no. 243 is reference book.

SCHELLEN (H.): Spectrum Analysis. (Transl. from 3d edit. by JANE and CAROLINE LASSELL), ed. by WM. DE W. ABNEY. ϕ, (14 plates, 2d edit.) London, 1885; 1 vol., O, no. 318.

SECCHI (A.): Le Soleil. ϕ, (2d edit., rev. et augmentée,) 1 pt., texte. Paris, 1875; 1 vol., O, no. 151.

——: Le Soleil. ϕ, (2d edit., rev. et augmentée,) 1 pt., texte. Paris, 1875; 1 vol., O, no. 152.

——: Le Soleil, Atlas. ϕ, (6 double plates.) Part 1. Paris, 1875; 1 vol., sq. O, no. 157 reference book.

——: Catalogo delle stelle. ϕ. (1 plate.) Paris, 1867; 1 vol., O, no. 192.

——: *See* MOIGNO.

SIDEREAL MESSENGER: Northfield. 7 vols. O, vol. 2, no. 70; vol. 3, no. 71; vol. 4, no. 72; vol. 5, no. 73; vol. 6, no. 74; vol. 7, no. 305; vol. 8, no. 75.

SIRIUS: Zeitschrift für populäre Astronomie. ϕ, Popular Journal, ed. by R. FALB. Leipzig, 1874–77; 5 vols., O, nos. 223–227.

SIRIUS: Same Journal, ed. by Dr. HERMANN KLEIN. ϕ, Leipzig, 1878–85; 8 vols., O, nos. 228–235.

SMYTH (C. P.): Teneriffe, an Astronomer's Experiment. ϕ, (Illustr.) London, 1858; 1 vol., D, no. 317.

SMYTH (W. H.): Cycle of Celestial Objects. (2d edit., rev. and enl. by GEO. CHAMBERS.) ϕ, Oxford, 1881, 1 vol., O, no. 316.

SNELL: *See* OLMSTED.

ST. LOUIS (Washington University Eclipse Party): Report on the Total Eclipse of the Sun, Jan. 1st, 1889; observations made at Norman, California. Cambridge, 1891; 1 vol., Q, no. 509.

STONE (E. J.): *See* OXFORD.

STUBBS (J. W.): *See* BRINKLEY.

SUNDERLAND (West Hendon House Observatory): No. 1, The Structure of the Sidereal Universe, by T. W. BACKHOUSE. Sunderland, 1891; 1 vol., Q, no. 528, reference book.

SYDNEY (Observatory): Photographs of the Milky-Way and Nebulae. Sydney, 1890; 1 vol., Q, no. 529, reference book.

TACUBAYA (National Observatory): Anuario para el año, 1890. Mexico, 1889; 1 vol., S, no. 95.

TERBY (F.): Aréographie ou étude comparative des observations faites sur l'aspect physique de la planète *Mars*. ϕ, Brussels, 1875–89; 1 vol., Q, no 90.

——: Observations divers. (From Bulletin of Académie Royale de Belgique), 1875–83. Brussels, 1875–83; 1 vol., O, no. 113.

THORNTON (J.): Physiography. ϕ, (6 maps, 180 illustr. and plates of spectra.) London, 1890; 1 vol., D, no. 260.

TODD (D. P.): *See* WASHINGTON (Smithsonian Inst.).

——: *See* WASHINGTON (Reports).

VOIRON (M.): Histoire de l'Astronomie, 1781–1811. ϕ, Paris, 1811; 1 vol., Q, no. 150.

WALLIS (T. H.): Catalogue of the California State Library. ϕ, Sacramento, 1889; 1 vol., O, no. 81, reference book.

WARREN (H. W.): Recreations in Astronomy. ϕ, New York, 1888; 1 vol., D, 4 copies, nos. 4–7; no 5 a reference book.

WASHINGTON (National Academy of Sciences): Memoir. Report of Eclipse Expedition to Caroline Islands, May, 1883, by E. S. HOLDEN. Washington, 1883; 1 vol., F, no. 102.

WASHINGTON (Reports of U. S. Departments): Solar Eclipses. I. An account of the Total Eclipse of the Sun on Sept. 7th, 1858, observed near Olmos, Peru, by Lieut. J. M. GILLIS. II. Reports of Observations of the Total Eclipses of the Sun, Aug. 7, 1869, by U. S. Coast Survey. III. The Total Eclipse of the Sun on July 29, 1878. Supplement to Nautical Almanac. IV. Observations of the Total Solar Eclipse of July 29, 1878, by Professor S. NEWCOMB and others. V. Report of the Total Solar Eclipse of July 29, 1878, by D. P. TODD. VI. Observations at Pike's Peak, Colorado, by Professor S. P. LANGLEY. (July 29, 1878.) VII. Annular Eclipse of the Sun, March 15–16, 1885, by ALLAN D. BROWN and A. G. WINTERHALTER. Washington; 1 vol., F, no. 113.

WASHINGTON (Smithsonian Institution): Annual Report, July, 1888. Washington, 1890; 1 vol., O, no. 520.

——: The Corona. Photographs taken during Eclipse, Jan. 1, 1889, with discussion. Structure of the Corona by D. P. TODD; Solar Corona by F. H. BIGELOW. (2 plates.) Washington, 1889; 1 vol., F, no. 100.

WASHINGTON (Naval Observatory): *Observations*, 1851–52, 1863, 1884–85. Washington; 4 vols., Q, nos. 219–220, 504–505; nos. 219–220 are reference books.

——: Report of the Superintendent, 1886. Washington, 1891; 1 vol., Q, no. 527, reference book.

WASHINGTON (War Department): Professional Papers of the Signal Service. No. 15, Solar Heat, by S. P. LANGLEY. Washington, 1884; 1 vol., Q, no. 210.

WATSON (J. C.): Popular Treatise on Comets. Philadelphia, 1861; 1 vol., D, no. 258.

WEBB (T. W.): Celestial objects for common telescopes. ϕ, (4th edit. rev., maps.) London, 1881; 1 vol., 4 copies, nos. 8–11; no. 10 is reference book.

WEINEK (L.): *See* PRAGUE Observatory.

WHEELER (G. M.): U. S. Geographical Surveys west of the 100th meridian. Washington, 1889; 1 vol., Q, no. 207, reference book.

WHEWELL (W.): Plurality of Worlds; also a dialogue on the same subject. ϕ, (2d and 5th edit.) London, 1859; 1 vol., S, 2 copies, nos. 323–332.

WILLIAMS (A. S.): Zenographical Fragments. The motions and changes of the markings on *Jupiter.* (Illustr., 8 plates.) London, 1889; 1 vol., O, no. 251.

WILLIAMS (W. M.): Fuel of the Sun. ϕ, (2d edit.) London, 1890; 1 vol., O, no. 269.

WINTERHALTER (A. G.): International Astrophotographic Congress. Washington, 1889; 1 vol., Q, no. 507.

YARNALL (M.): Catalogue of Stars observed at the U. S. Naval Observatory, 1845–77. (3d edit., rev. and cor.) Washington, 1889; 1 vol., Q, no. 211, reference book.

YOUNG (C. A.): Elements of Astronomy. ϕ, Boston, 1890; 1 vol., D, 5 copies, nos. 29–33; no. 33 is reference book.

——: Text-book of General Astronomy. ϕ, Boston and London, 1889; 1 vol., O, 3 copies, nos. 76–78; no. 76 is reference book.

——: The Sun. ϕ, (3d edit. illustr.) New York, 1888; 1 vol., D, 2 copies, nos. 46–47; no. 46 is reference book.

PART II.—UNBOUND BOOKS AND PAMPHLETS.

APPEL (D.): Die freie Schwerkraft-Hemmung der Normal-Stern-Uhr zu Princeton, N. J. (Extract from *Zeitschrift für Instrumentenkunde.*) Berlin, 1886, 2 copies; O.

ARCHIVES *des Science Physiques et Naturelles:* Tome 25, no. 5. Genève, 1891; O.

ASTRONOMICAL JOURNAL: Vol. 8, no. 8, 1888. Cambridge; Q.

BAILY (F. H.): Primary Phenomenal Astronomy. Northfield, 1886; S.

BAKHUYSEN (H. v. d. S.): Verslag van den Staat der Sterrenwaght te Leiden, etc. (22 Sept., 1886—18 Sept., 1888.) Leiden, 1888–89; O.

BALL (L. de): Masse de la Planète *Saturne.* Bruxelles, 1887; Q.

BARNARD (E. E.): Observations of the Eclipse of *Japetus* in the Shadows of the Globe, Crape Ring and Bright Ring of *Saturn*. (Reprinted from *Mon. Not.* R. A. S., vol. 50, no. 3); O.

BERKELEY (University of California): Announcement of Courses in Mathematics, 1891. Berkeley, 1891, 2 copies; S.

BERLIN (Gesellschaft URANIA): Statuten. Berlin, 1889; O.

BIGELOW (F. H.): The Solar Corona discussed by Spherical Harmonics. Washington, 1889; Q.

BIGOURDAN (G.): Nebuleuses nouvelles, découvertes à l'Observatoire de Paris. Paris, 1888–91; Q.

BOEHMER (G. H.): Report on Astronomical Observatories for 1886. Washington, 1889; O.

BRUENNOW (F.): Astronomical Notices, nos. 1–2–3–4–5–6–7–8–9–10–11–12–13–14–15–16–17–18–19–20. Ann Arbor, 1858; O.

BRÜNNOW (F.): Tables of *Victoria*. New York, 1859; Q.

BRUXELLES (Observatory): HOUZEAU (J. C.). Catalogue Méthodique des Ouvrages, des Mémoires et des Observations Astronomiques depuis les temps anciens jusqu' à l' époch actuelle. Bruxelles, 15 copies; Q.

BUFF & BERGER: Hand-Book and Illustrated Catalogue of Engineers' and Surveyors' Instruments. Boston, 1885; O.

BURCKHALTER (C.): Total Solar Eclipse, Jan. 1, 1889. (Reprinted from *The Sidereal Messenger*, no 73.) O.

BURNHAM (S. W.): An Examination of the Double-Star Measures of the Bedford Catalogue. (Reprinted from *Mon. Not.* R. A. S., vol. 40, no. 8); O.

——: Report to the Trustees of the "JAMES LICK Trust" of Observations made on Mt. Hamilton with reference to the Location of the Lick Observatory. Chicago, 1880; Q.

——: The Trapezium of *Orion*. (Reprinted from *Mon. Not.* R. A. S., vol. 49, no. 6); O.

CALLANDREAU (O.): Étude sur la Théorie des Comètes Périodiques. Paris; Q.

CHARLIER (C. L. V.): Ueber die Anwendung der Sternphotographie zu Helligkeitsmessungen der Sterne. Leipzig, 1889; Q.

CHICAGO (Astronomical Society): *Annual Report* of the Board of Directors, 1887. Chicago, 1887; O.

CHITTENDEN (R. H.): Studies in Astronomy, no. 111. Marshall, 1889; O.

CINCINNATI (Observatory): *Publications*, 1882-86, 1887-91, nos. 9-11. Cincinnati, 1887-90-91; O.

DENNING (W. F.): Catologue of Bright Meteors observed at Bristol during the years 1877 to 1889, inclusive. (Reprinted from *Mon. Not.* R. A. S., vol. 50, no. 2); O.

——: Catalogue of 918 Radiant Points of Shooting Stars observed at Bristol. (Reprinted from *Mon. Not.* R. A. S.); O.

DENVER: (Chamberlin Observatory of the University of Denver.) *Publications*, no. 1. (Solar Eclipse of Jan. 1, 1889.) Denver, 1889; O.

DOBERCK (W.): Observations and Researches made at the Hongkong Observatory in the year 1884. Hongkong, 1885; Q.

DÖLLEN (W.): Zeitstern-Ephemeriden aüf das Jahr, 1886-87. St. Petersburg, 1886; Q.

DONNER (A.): Beobachtungen von Cometen angestellt auf der Sternwarte zu Helsingfors im Winter und Frühjahr, 1885-86. Helsingfors, 1889; Q.

——: Formel und Tafeln zur Berechnung von Zeitbestimmungen durch Höhen in der Nähe des ersten Vertikals. Helsingfors, 1890; O.

DREYER (J. L. E.): A New General Catalogue of Nebulae and Clusters of Stars. (Memoirs of the R. A. S., vol. 49, pt. 1. London, 1888); O.

DUNÉR (N. C.): Recherches sur la rotation du Soleil. (Présenté à la Société Royale des Sciences d'Upsal, le 14 Février, 1891.) Upsala, 1891; Q.

FEARNLEY (C.) und GEELMUYDEN (H.). Zonenbeobachtungen der Sterne zwischen 64° 50′ und 70° 10′ nördlicher Declination auf der Universitäts Sternwarte in Christiania. Christiania, 1888; Q.

FUNK (C.): Nachtrag zu meinem Aphoristischen Entwurf einer Kosmogonie, 1889; O.

GALILÉE, LE: No. 8. Paris, 1890; O.

GEELMUYDEN (H.): *See* FEARNLEY.

GEORGETOWN (College Observatory): *Publications:*—I. The Photochronograph by G. A. FARGIS. II. Results of the Photographic Transits by JOHN G. HAGEN. Washington, 1891; Q.

GREENWICH (Royal Observatory): *Reports of the Astronomer Royal* to the Board of Visitors (1875–6) (1888–9). Greenwich; Q.

GRUBB (HOWARD): Great Telescopes of the Future. Dublin, 2 copies; Q.

——: Catalogue of Astronomical Instruments. Dublin, 1877–80, 3 copies; Q.

——: Illustrated Catalogue of Astronomical Instruments, Observatories, etc. Dublin, 1886, 3 copies; Q.

HAGEN (J. G.); *See* FARGIS.

HAGEN (J. G.) and HOLDEN (E. S.): A Catalogue of 1001 Southern Stars for 1850, from observations by Signor TACCHINI, at Palermo, in the years 1867–1868–1869. Madison; O.

HALL (ASAPH): *Saturn* and its Ring, 1875–89. Washington, 1889; Q.

HARRISON (HENRY): A Hand Book of Telescopic Pictures of the Moon. New York, 1880; O.

HASTINGS (C. S.): *See* HOLDEN.

HELSINGFORS (Observatory): *See* DONNER.

HERSCHEL (Sir W.): *See* HOLDEN and HASTINGS.

HILFIKER (J.): L'influence de la Pression de l'air sur la Marche des Chronomètres. Neuchatel, 1889; O.

HILL (CHAS. B.): Astronomical Photography. (A Lecture delivered Sept. 9, 1889, before the Cosmos Club of San José.) O.

HOLDEN (E. S.): Progress of Astronomy for 1878. Washington, 1878; S.

——: Catalogue of the Library of the United States Naval Observatory. (Part I. Astronomical Bibliography.) Washington, 1879; Q.

——: Observations of the Comet "B," 1881, made at the Washburn Observatory, University of Wisconsin. Madison, 1881; O.

——: List of Red Stars, observed at the Washburn Observatory. Dublin, 2 copies; Q.

HOLDEN (E. S.): Investigation of the Objective and Micrometers of the Twenty-Six Inch Equatorial constructed by ALVAN CLARK & SONS. Washington, 1881; Q.

——: An Account of Recent Progress in Astronomy in the years 1879 and 1880. Washington, 1881–2–5; O.

——: An Account of the Progress in Astronomy in the year 1882. Washington, 1883; O.

——: List of Recorded Earthquakes in California, Lower California, Oregon and Washington. 1769–1887. Sacramento, 1887; O.

——: Suggestions for observing the Total Eclipse of the Sun, on Jan. 1, 1889. Sacramento, 1888; O.

——: Observations on the Light of Telescopes used as Night-Glasses. (From *Am. Jour. Sci.*, vol. 22, August, 1881.) O.

——: Note on Earthquake Intensity in San Francisco. (From *Am. Jour. Sci.*, vol. 35, June, 1888.) O.

——: The Lick Observatory. (Abstract from the first volume of the *Publications* of the Lick Observatory.) O.

——: The Total Solar Eclipse of 1889, Jan. 1, in California. Probable Meteorological conditions at that time. (Reprinted from *Mon. Not.* R. A. S., vol. 48, no. 6.) 2 copies; O.

——: Observations of Nebulae at the Lick Observatory. (Reprinted from *Mon. Not.* R. A. S., vol. 48, no. 9.) O.

——: The Photographs of the Corona at the Solar Eclipse of 1889, Jan. 1. (Reprinted from *Mon. Not.* R. A. S. vol. 49, no. 6.) O.

——: Some of the Features of the Arrangement of Stars in Space. (Reprinted from *Mon. Not.* R. A. S., vol. 50, no. 2.) O.

——: The Photographic Apparatus of the Great Equatorial of Lick Observatory. (Reprinted from *Mon. Not.* R. A. S., vol. 50, no. 3.) O.

——: Die Helikalischen Nebel. (From *Himmel und Erde.*) Berlin; O.

—— and HASTINGS (C. S.): A Synopsis of the Scientific Writings of Sir WM. HERSCHEL. Washington, 1881; O.

——: *See* HAGEN.

——: *See* Mount Hamilton (Lick Observatory).

HONGKONG (Observatory): *See* DOBEREK.

HUGGINS (WM.): The Solar Corona. London, 1885; O.

JANSSEN (J.): Compte rendu d'une ascension scientifique au Mont Blanc. (Extrait des *Comptes rendus*), t. cxi, 22 Séptembré, 1890; Q.

JOURNAL DU CIEL: Nos. (1046–7) (1048–9) (1052–3) (1854–5) (1856–7) (1858–9) (1060–1) (1062–3) (1064–5). [Editor] JOSEPH VINOT. Paris, 1891; Q.

KEELER (J. E.): The Motions of the Planetary Nebulae in the Line of Sight. (Extract from the *Publications* of the Astronomical Society of the Pacific, vol. 2, no. 11.) San Francisco, 1890; O.

KIEL (Observatory): *Publicationen.*—IV. Anhang zu den Zonenbeobachtungen der Sterne zwischen 55 und 65 Grad nördlicher Declination angestellt an den Sternwarten zu Helsingfors und Gotha. Kiel, 1890; Q.

——: I. Das Aequinoctium für 1860, von Dr. E. LAMP. II. Der grosse September Comet 1882 II von Dr. HEINRICH KREUTZ. Kiel, 1882–91; Q.

KLOOCK (H.): Tafel für das dritte Glied der Praecession. Kiel, 1890; Q.

KNOPF (OTTO): Kurze historische Notizen über die Sternwarte zu Jena. (Extract from V. J. S. Astron. Gesellschaft, Jahrg. 26, Heft 2.) O.

KÖHL (TORVALD): Den Astronomiske Husven. Kjobenhavn, 1883; O.

KOWALSKI (M.): Recherches sur la Réfraction Astronomique. Kasan, 1878; O.

KREUTZ (H.): Untersuchungen über das Cometen System 1843 I, 1880 I und 1882 II. Kiel, 1888; Q.

——: *See* KIEL.

LAMP (E.): *See* KIEL.

LANCASTER (A.): Liste Générale des Observatoires et des Astronomes, des Sociétés et des Revues Astronomiques. Bruxelles, 1890; T.

LANGLEY (S. P.): The Temperature of the Moon. (From *Am. Jour. Sci.*, vol. 38.) O.

——: The Temperature of the Moon. Washington, 1889; Q.

——: The Observation of Sudden Phenomena. (From *Am. Jour. Sci.*, vol. 38, August, 1889.) O.

Langley (S. P.) and Very (S. W.): The Cheapest Form of Light, from Studies at the Allegheny Observatory. (From *Amer. Jour. Sci.*, vol. 40, August, 1890.) o.

Leipzig: (Astronomische Gesellschaft) Vierteljahrsschrift, vol. 25, (parts 1, 2, 3, 4.) 26, (1, 2,) Leipzig, 1890; o.

——: (Catalog der Astronomischen Gessellschaft) *Vierzehntes Stück* Zone + 1° bis + 5°, beobachtet auf der Sternwarte Albany. *Viertes Stück* Zone + 55° bis 65°, beobachtet auf den Sternwarten Helsingfors und Gotha. *Drittes Stück* Zone + 65° bis 70°, beobachtet auf der Sterwarte Christiania. Leipzig, 1890; Q.

Leyden (Observatory): *Annalen*, vols. 5, 6. Haag, 1890; Q.

Lick (James): Deed of Trust dated Sept. 21, 1875. San Francisco; o.

Liverpool (Astronomical Society): *Catalogue of the Library.* Liverpool, 1888; o.

Loewy (M.): Éphémérides des étoiles de culmination lunaire et de longitude pour 1890. Paris, 1889; Q.

London (Royal Astronomical Society): Monthly Notices. Vol. 49, nos. 7–9, 1889; vol. 50, nos. 1–9, with appendix, 1889–90; vol. 51, nos. 1–8, with list of fellows, 1890–91; London, 1889–90–91; o.

London (British Astronomical Association): *Journal*, vol. 1, nos. 1–9, 1890–91. List of Members, 1890. London, 1890–91; o.

Loomis (E): [Memoir of]. *See* Newton (H. A.).

Madison (Washburn Observatory): *Publications*, nos. 1 and 2, vol. 6; no. 1, vol. 7. Madison, 1890; Q.

Marth (A.): A List of published Lunar Sketches and Photographs arranged according to the Sun's Position. Ephemeris for Physical Observations of the Moon. Ephemeris of the Satellites of *Uranus*, 1892. (Reprinted from *Mon. Not.* R. A. S., vol. 51, no. 3.) 2 copies; o.

——: Two Auxiliary Tables for the Solution of Kepler's Problem. Ephemerides of the Satellites of *Saturn*, 1890–1. Ephemerides of the Satellites of *Neptune*, 1890-1. (Reprinted from *Mon. Not.* R. A. S., vol. 50, no. 9.) 2 copies; o.

MARTH (A.): On the Computation of the Equation of the Centre in Elliptical Orbits of Moderate Eccentricities. (Reprinted from *Mon. Not.* R. A. S., vol. 50, no. 8.) 2 copies; O.

——: I. Ephemerides of the Satellites of *Saturn*, 1889–90. II. Ephemerides of the Satellites of *Neptune*, 1889–90. (Reprinted from *Mon. Not.* R. A. S., vol. 49, no. 9.) O.

——: Ephemeris for Physical Observations of *Jupiter*, 1890. (Reprinted from *Mon. Not.* R. A. S., vol. 50, no. 5.) 2 copies; O.

——: Ephemerides for Physical Observations of the Moon. (Reprinted from *Mon. Not.* R. A. S.) 2 copies; O.

——: Ephemerides of the Satellites of *Saturn*, 1890–1. (Reprinted from *Mon. Not.* R. A. S., vol. 51, no. 1.) 3 copies; O.

——: Ephemerides of the Satellites of *Saturn*, 1889–90 (concluded.) (Reprinted from *Mon. Not.* R. A. S., vol. 50, no. 1.) 2 copies; O.

MELBOURNE (Observatory): Second Melbourne Catalogue of 1211 Stars for the Epoch 1880. Melbourne, 1889; Q.

MEXICO (Sociedad Cientifica "Antonio Alzate"): *Transactions.*—(Vol. 3) 2–7–8–9–10–11–12; (Vol. 4) 1–2–3–4–5–6–7–8–9–10. Mexico, 1882–6–7–9, 1890–1; O.

MILWAUKEE (Public Library): Twelfth Annual Report of the Board of Trustees, Oct. 1, 1889. Milwaukee, 1889; O.

MONCK (W. H. S.): Stationary or Long-enduring Meteor-Radiants. S.

MOUNT HAMILTON (Lick Observatory): Report on the Observations of the Total Eclipse of the Sun, Dec. 21–22, 1889, and of the Total Eclipse of the Moon, July 22, 1888, to which is added a Catalogue of the Library of the Lick Observatory. Sacramento, 1891; O.

MUNICH (Observatory): (*Neue Annalen*) Band I. München, 1890; Q.

NEWCOMB (SIMON): Report to the Secretary of the Navy on Recent Improvements in Astronomical Instruments. Washington, 1884; O.

NEW HAVEN (Winchester Observatory): Yale College—Report of the Board of Managers to the President and Fellows for the Academic Year 1880–81, to which is appended the Report of the Astronomer in charge of the Horological and Thermometric Bureaux. Also Reports 1881–91. New Haven, 1881–91; O.

NEW HAVEN (Yale University Observatory): *Transactions.*—Vol. I, Part 1, 1887; Vol. II, Part 2, 1889. New Haven, 1887–9; Q.

NEWTON (H. A.): ELIAS LOOMIS, LL. D., 1811–1889 [Memoir of]. New Haven, 1890; O.

——: An Address before the American Association for the Advancement of Science at Detroit, August, 1875. Salem, 1875; O.

NEW YORK (Mathematical Society): *Organization of*, etc. New York, 1891; O.

OBSERVATORY (The): A Monthly Review of Astronomy, nos. 131–147–151. London, 1888–9; O.

(The) PACIFIC MONTHLY: Nos. 1–2, vol. 1, 1889. [Containing two articles by E. S. HOLDEN.] Los Angeles; O.

PARIS (Observatory): *See* BIGOURDAN.

—— (Department of Public Instruction): Rapport sur les observatoires astronomiques de Province. Paris, 1889–90; O.

—— (Bureau des Longitudes): *Connaissance des Temps* ou des mouvements Célestes a l'usage des Astronomes et des Navigateurs pour l'an 1891–92. Paris, 1889–90. Q.

——: *Annuaire* pour l'an 1889. Paris, 1889; T.

——: *Annales.* Tome Quartrième. Paris, 1890; Q.

PERRY (S. J.): Stonyhurst College Observatory. Results of Meteorological and Magnetical Observations, 1885. Roehampton, 1886; S.

PETERS (C. A. F.): Bestimmung des Längenunterschiedes zwischen den Sternwarten von Altona und Kiel. Kiel, 1873; Q.

PETRELUIS (ALFRED): Tabeller för beräkning af Barometriska Höjdmätningar. Helsingfors, 1890; O.

PICKERING (E. C.): A Plan for securing Observations of the Variable Stars. Cambridge, 1882, 3 copies; O.

PORRO (FRANCESCO): Sulle Determinazioni di Latitudine eseguite negli anni 1888–9–90, all'osservatorio di Torino. Torino, 1890; O.

——: Sulla Stella Variabile U *Orionis*. Torino, 1890; O.

PROCTOR (R. A.): Old and New Astronomy. Parts 1–10. London, 1888; Q.

RAJNA (MICHELE): Sul Metodo Grafico Nel Calcolo delle Eclissi Solari. Milano, 1891; O.

RIZZO (G. B.): Osservazioni Meteorologiche fatte nell' anno 1888, All' Osservatorio della Universita di Torino. Torino, 1890; O.

ROCHESTER (Warner Observatory): History and Work. Rochester, 1887; O.

ROME (*Societá Degli Spettroscopisti Italiani*): *Memoire*, 1889—vol. 18, no. 5 to 12; 1890—vol. 19, no. 1 to 12; 1891—vol. 20, no. 1 to 5. Rome, 1889–90–1; F.

RUSSELL (H. C.): President's Address at the First Meeting of the Australasian Association for the Advancement of Science. Sydney; O.

——: The Source of the Underground Water in the Western Districts. (Read before the Royal Society of N. S. W., Aug. 7, 1889.) O.

——: Results of Rain, River and Evaporation Observations made in New South Wales during 1888. Sydney, 1889; O.

——: Astronomical and Meteorological Workers in New South Wales, 1778–1860. [From "Proceedings Australasian Association for the Advancement of Science." Sydney, 1888;] O.

——: A New Self-Recording Thermometer. (Read before the Royal Society N. S. W., November, 1888;) O.

——: Results of Meteorological Observations made in New South Wales during 1887. Sydney, 1889; O.

——: The Storm of the 21st Sept., 1888. (Read before the Royal Society of N. S. W., Oct. 3, 1888;) O.

——: The Thunder Storm 26th Oct., 1888. (Read before the Royal Society N. S. W., Nov. 7, 1888.) O.

SAN FRANCISCO (Astronomical Society of the Pacific): *Publications*, nos. 1 to 16, vol. 1–2–3. San Francisco, 1889–91; O.

—— (California Academy of Sciences): *Proceedings*, vol. 1, parts 1 and 2, 1888–9; vol. 2, part 1, 1889; San Francisco, 1888–89–90; O.

SAN FRANCISCO (Technical Society of the Pacific Coast): *Transactions*, vol. 7, nos. 2–4–5; vol. 8, no. 1.) San Francisco, 1890–1; O.

SAFFORD (T. H.): Commemoration of the Fiftieth Anniversary of the Dedication of the Hopkins Observatory, Williams College, 1888. Williamstown, 1888; O.

SCHIAPARELLI (G. V.): Sulla Distribuzione Apparente Delle Stelle. Milano, 1889; Q.

——: Considerazioni sul moto rotatorio del pianeta *Venere*, Nota 4ª–5ª. (Estratto dai *Rendiconti* del R. Istituto Lombardo.) Milano, 1890; O.

SCHORR (RICHARD): Untersuchungen über die Bewegungsverhältnisse in dem dreifachen Sternsystem ξ Scorpii. München, 1889; Q.

SCHULTZ-STEINHEIL (C. A.): Definitive Bahnelemente des Kometen 1840 IV. Stockholm, 1890; Q.

SCHWARZ (L.): Eine Studie auf dem Gebiete der Practischen Astronomie. Dorpat, 1889; Q.

SIDEREAL MESSENGER: 1885, vol. 4, no. 34; 1888, vol. 7, no. 62; 1889, vol. 8, nos. 73, 76–80; 1890, vol. 9, nos. 81–90; 1891, vol. 10, nos. 91–97. Northfield; O.

SIRIUS (Zeitschrift für populäre Astronomie): Vol. 24, nos. 1–8. Leipzig, 1891; O.

SMYTH (C. PIAZZI): Report on the Royal Observatory, Edinburgh, for June 30, 1888, and the Edinburgh Equatorial in 1887. Clova, Ripon, 1888; Q.

STOCKWELL (JOHN N.): Secular and Long-Period Inequalities in the Moon's Motion. (From *Astronomical Journal*, nos. 220–221.) Lynn; Q.

STONE (ORMOND): An Address before the Section of Mathematics and Astronomy, A. A. A. S. Salem, 1888; O.

——: On the Motion of *Hyperion*. (Reprint from Annals of Mathematics, vol. 5, no. 2, October, 1889.) Q.

STONYHURST (Observatory): *See* PERRY (S. J.).

STRUVE (LUDWIG): Bestimmung des Mondhalbmessers aus dem während der totalen Mondfinsterniss, 1884, Oct. 4, beobachteten Sternbedeckungen. Dorpat, 1889; Q.

SYDNEY (Observatory): *See* RUSSELL (H. C.).

TACCHINI (P.): *See* HAGEN and HOLDEN.

TACUBAYA (National Astronomical Observatory): *Boletin*, 1890, Tomo 1, nos. 1-2-3-4-5. Tacubaya, 1890; Q.

TAYLOR (WM. B.): An Address delivered before the Philosophical Society of Washington. Washington, 1882; O.

TEBBUTT (J.): Report on Mr. TEBBUTT's Observatory, The Peninsula, Windsor, New South Wales, 1888-89-90. Sydney; O.

——: History and Description of Mr. TEBBUTT's Observatory, Windsor, N. S. W. Sydney, 1887; O.

TERBY (F.): A Propos de la découverte de la Rotation de *Mercure*. (Extrait des Bull. de l'Acad. roy. de Belgique, 3. série, tome 19, no. 1, 1890.) Brussels; O.

TODD (D. P.): Photographs of the Corona taken during the Total Eclipse of the Sun, Jan. 1, 1889. Washington, 1889; Q.

——: Instructions for observing the Total Eclipse of the Sun, Jan. 1, 1889. Amherst, 1888; Q.

——: *See* WASHINGTON.

TORONTO (Canadian Institute): *Transactions*, vol. 1, no. 1, 1890. Toronto, 1890; O.

TURIN (Observatory): Effemeride del Sole e della Luna, per l'orizzonte di Torino e per l'anno, 1889-90-91. Torino, 1888-89-90; O.

——: *Bollettino*. Anno 22, 1887. Torino, 1889; Q.

——: *See* RIZZO.

UNIVERSITY OF VIRGINIA (LEANDER MCCORMICK Observatory): *Publications*, no. 5. Charlottsville, 1890; O.

UPSALA (Observatory): Iakttagelserna för Equinoktiets Bestämning, 1889. K. BOHLIN and C. A. SCHULTZ-STEINHEIL. Stockholm, 1890; Q.

VENTOSA (D. V.): Método para Determinar la Direccion del Viento. Barcelona, 1890; O.

——: La Direction des vents supérieurs déterminée par les ondulations du bord des astres. Bruxelles, 1890; O.

VERY (F. W.): *See* LANGLEY.

VIENNA (Observatory): *Annalen*. vols. 2-3-4-5-6. Vienna, 1884-88; Q

WALDO (LEONARD): An Address to the Yale Club of Cincinnati in behalf of the Observatory of Yale College, March, 1890. O.

WASHINGTON (U. S. Naval Observatory): *Report of the Superintendent* for 1885–6–7–8–9 and 90. Washington; o.

——: Reports on the removal of. Washington, 1887; o.

——: Observations of the Brightness of the Satellites of *Uranus*, o.

WASHINGTON (American Ephemeris): Pacific Coaster's Nautical Almanac, 1888–9. Washington, 1887–8; o.

WASHINGTON (Bureau of Navigation): Almanac Catalogue of Zodiacal Stars. Washington, 1864; o.

WASHINGTON (Smithsonian Institution): *Report* for 1889): Washington, 1890; o.

——: Report on Astronomical Observatories 1880 (no. 438). Washington, 1881; o.

WASHINGTON (U. S. Scientific Expedition to West Africa, 1889–90): *Bulletins*, nos. 4–8–12–13–15–16. *See* D. P. TODD.

WASHINGTON (U. S. Transit of *Venus* Commission): Instructions for observing the Transit of *Venus*, Dec. 6, 1882. Washington, 1882; Q.

WEISS (EDMUND): Katalog der ARGELANDER'schen Zonen vom 15. bis 31. Grade südlicher Declination in Mittleren Positionen für 1850. I. Supplementband. Wien, 1890; o.

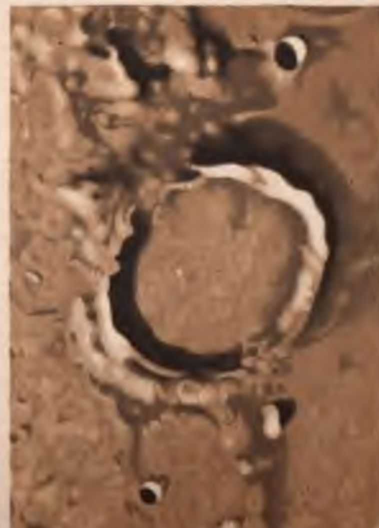
(The) WEST AMERICAN SCIENTIST: NOS. 1–15–20–21–23–24–28–29–30–37–38-39–43–45–46–47–48–49–50–51–52–53–55–56–57–58-59. San Diego, 1886–91; o.

WHITE (E. J.): Second Melbourne Catalogue of 1211 Stars for 1880.0. Melbourne, 1889; Q.

WILLIAMS (Justice) Opinion—CHRISTIAN H. F. PETERS, Plaintiff, *vs.* CHARLES A. BORST, Defendant. Utica, 1889; o.

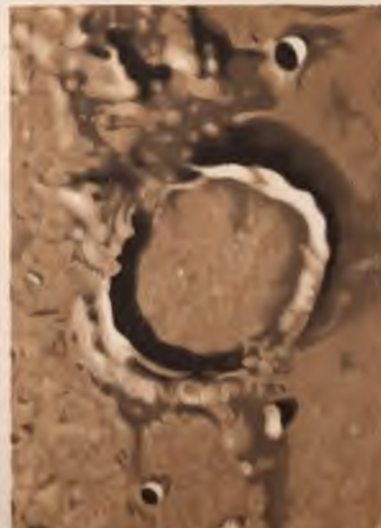
WILSON (HERBERT O.): Catalogue of 644 Comparison Stars. Northfield, 1890; Q.

WINLOCK (WM. C.): An Account of the Progress of Astronomy in the year 1885. Washington, 1886; o.



ARCHIMEDES

drawn by Professor Dr L. Weinek, from negatives taken in the focus of the 36-inch refractor of the Lick Observatory, August 15 and 27, 1888



ARCHIMEDES

drawn by Professor Dr. L. Weinek, from negatives taken in the focus of the 36-inch refractor of the Lick Observatory, August 15 and 27, 1888

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

VOL. III. SAN FRANCISCO, CALIFORNIA, NOVEMBER 28, 1891. NO. 19.

ENLARGED DRAWINGS FROM LUNAR PHOTOGRAPHS TAKEN AT THE LICK OBSERVATORY.

BY PROF. DR. L. WEINEK OF PRAGUE.*

In November, 1889, Professor EDWARD S. HOLDEN kindly made the proposition to me that he would send to Prague a series of the best negatives of the moon, taken with the 36-inch refractor of the Lick Observatory, in order that they might serve as a basis for my drawings of lunar craters and lunar landscapes made at the telescope, as well as to furnish subjects for special studies of the moon's surface. I was all the more eager to entertain such a proposition, because the Prague Observatory is possessed of only a six-inch telescope on a very inconvenient mounting, and because the opportunity was offered to take part in the magnificent results of the—at present—largest instrument in the world.

Up to this time I had made fifty-four lunar drawings at the telescope, and I was justified, by reason of considerable practice of eye and hand, in taking up this new labor.

Since the beginning of the year 1890, Professor HOLDEN has sent to Prague continuously a large number of plates for the different days of a lunation, and I am greatly indebted to him for creating an incentive to do this work, as well as for the valuable donation of these beautiful plates to the Prague Observatory from the Lick Observatory.

For the purpose in view I had built at Dresden a suitable apparatus before beginning the task. In this the photographic plate is viewed by transmitted light by means of two eye pieces of 41.15 and 25.20 millimetres (equivalent) focus. (Linear enlargement = 7.8 and 12.1 for my distinct vision of 28 centim.) The holder or

* Translated for the Society by OTTO VON GELDERN, Esq.

stand of the eye-pieces possessed a double motion in two co-ordinate directions normal to each other; it admitted of a ready and rapid adjustment of the portion of the moon viewed, and kept the chosen lens at a constant distance from the plate. The illumination of the latter may be obtained by daylight or by means of a lamp; in the case of the former a parabolic reflector may be so set or turned as to furnish the desired degree of light. For drawing, diffused daylight is used, by inserting a dull ground glass between the plate and the reflecting mirror. The window at the left hand of the draughtsman throws light at the same time on the small drawing-board which holds the paper. A handy little drawing-table attached to the lower part of the apparatus, completes the outfit. That the person engaged in viewing or drawing may not become too easily fatigued, the plate with the mirror may be turned backward and set at will to any desired angle. The apparatus is arranged for large plates as well as for very small ones.

Since every direct photographic enlargement presents numerous defects, and will be found inferior to the original, particularly in strength and intensity, it was not a superfluous undertaking to prepare enlarged drawings or tintings from the original plates—drawings that were to be made in this case with the greatest exactness and absolute truth as to strength and clearness—for the reason, that work done in this manner may be continued at any time, and can be constantly controlled and improved upon.

In this particular *two* methods were available; the first, by having very faint photographic enlargements of certain particularly interesting portions of the lunar surface thrown upon suitable paper and by retouching them subsequently to the fullest intensity of the original; and the second, by discarding the photographic aid altogether and projecting a mathematically accurate enlargement to any desired scale, by means of suitable instruments, directly upon the best white drawing-paper, upon which the representation is then newly developed and entirely built up.

In the first or photographic method, which I used in making a four-fold enlargement of the *Mare Crisium*, from *Apollonius* in the south to *Geminus* in the north, taken from the beautiful Lick-exposure of August 23d, 1888, a work requiring 34¾ hours, I found it very unfavorable that the so-called salt paper (salz-papier), which is commonly in use in photographing coloring, is of so hygroscopic a nature that it requires the most careful and painstaking drying at a considerable expense of time; and again I have found that every photographic paper will lose in whiteness by reason of the chemical process it has to undergo, and in consequence will not admit of showing the lighter portions of the moon with sufficient brightness. It was principally for the latter reason that I soon adopted the second method. Since an exact tracing of contours was unavoidable, and having found that even the most transparent papers with millimetre graduations were unsatisfactory, I had glass scales made containing precise divisions into square millimetres. These as well as the above described drawing apparatus were made by the mechanician HEYDE of Dresden, who after a few trials succeeded in etching these scales. Such a scale is now laid, with its etched side down, upon the plate and held there by means of two springs at opposite ends; that part of the lunar surface which it is desired to enlarge is followed in the smaller squares on the glass, and reproduced in similar squares previously drawn on the paper to any required degree of enlargement. In this manner the originals of the two lithographic copies accompanying this paper, of the magnificent ring-plain of *Archimedes* were drawn, magnified ten times.

The picture on the left belongs to the Lick-exposure of August 15th, 1888 (age of the moon eight days), and required for its final and finished completion in tints 44¾ working hours, while the one on the right is from an exposure taken at the Lick Observatory on the 27th of August, 1888 (age of the moon twenty days), and required a working-time of 43 hours. Each is of a size of five by seven centimetres.

Let us now proceed to the scientific discussion of these drawings. In what follows the one on the left will be designated I, that on the right II.

At first glance it is recognized, that *Archimedes* appears somewhat larger on I than on II, although both drawings were magnified from the originals exactly ten times. From this it must be concluded that the lunar diameter of the photograph taken on the 15th of August, 1888, must have been larger than on the one taken August 27th, 1888. And indeed we find that, measuring in the line of the zero meridian (direction from the eastern wall of *Autolycus* to the west wall of *Ptolemy*) the diameter is 130.0 millimetres for the first named plate, while for the second it is only 119.7 millimetres. This is further explained by the fact that I was taken near the time of the moon's perigee (which took place on August 14th at 0^h Greenwich mean time) whereas II was obtained near the apogee of the moon (occurring on August 28th at 1^h Greenwich mean time). If for an approximation the corrections for refraction, parallax and libration be left unconsidered, the arithmetical mean of the dimensions of I and II may be looked upon as that corresponding to the mean distance of the moon from the earth, which, as well known, was used in the large lunar charts of one metre by LOHRMAN and MÄDLER, and the 2-metre chart made by SCHMIDT. Since the latter is based upon observations extending through a period of over thirty years, and is the most detailed, let us adopt it for the purpose of making our comparisons. *Archimedes* is shown upon section IV of the same. As far as the effects of libration are specially concerned, a simple reflection will show that on account of the juxtaposition of *Archimedes* to the central meridian, it is principally the libration in latitude that need be considered. Since the centre of the moon was 4° above the ecliptic on the 15th of August, and on the 27th 5° below it, the first exposure would necessarily show more of the southerly portions, and the second more of the northerly parts of the lunar surface. But since *Archimedes* is situated in about 30° selenographic latitude in the northern hemisphere, it follows that this walled-plain must lie nearer to the visible edge of the moon on I than upon II, which is confirmed by comparing the two photographs. For this reason the meridional dimensions of I must appear perspectively shortened and those of II perspectively lengthened, when compared with those that occur under a mean geocentric libration in latitude (the moon's centre being in the ecliptic); and in our case this must be so in nearly equal amounts, so that, roughly approximated, we may consider the mean of I and II as free from all libratory effects.

In order to make this subject intelligible to the reader without the aid of a contour drawing from I or II, and without adopting a nomenclature of figures or letters for the numerous objects of each picture; and in order to permit a most careful comparison with SCHMIDT'S chart, it will be well to characterize the single objects by means of polar-co-ordinates referred to some easily determined initial point. As such the centre of the ring-plain might be taken, provided that its periphery would prove sufficiently regular for the purpose. But this is not the case. I have therefore joined the centres of the two craters, located southeast and northwest from *Archimedes* respectively, crater A (shown in the picture in the upper right hand corner) and C (at the lower left hand), by drawing a straight line from one to the other; this line was bisected, and the point of bisection, which is nearly in the middle of *Archimedes*, was adopted as the initial point (O) of the co-ordinates. By the projection of this line A O C, as well as by drawing the lunar meridian passing through O upon SCHMIDT'S chart, the angle between the line OA and the direction O-South was found to be 51°. This angle properly laid off from AC on I and II, determines upon each picture the position of the meridian through O, and defines thus the cardinal points, north, south, east and west for the presented landscape. If furthermore the angle between O-North and O-Object, measured from the north around to the east, be called the position angle (p) of the object, the location of the latter will be absolutely fixed by this angle and the linear distance (d) of the object from O. It is also to be noted that when the lunar meridian is traced upon both pictures, it is found that this line appears upon II as though it were turned 15° towards the east in the upper part; this corresponds to the position of the line of the limit of light to the vertical edge of the plate in the exposures. The latter direction, however, was the necessary guide for the orientation of the enlarged drawing.

By comparing the distance AC upon I and II with the same distance upon SCHMIDT'S chart, we obtain at once the scale of my ten-fold enlargements, presuming that it is correctly given on the former. SCHMIDT gives AC = 83.5 (MÄDLER 43.0), on I it equals 61.0 and on II 57.0 millimetres. Since it is necessary to take the average of I and II, in order to reduce the moon to mean distance, the dimensions of the mean of both drawings are smaller than SCHMIDT'S in the proportion of 59.0 to 83.5. Every linear value of SCHMIDT'S chart therefore, if multiplied by 0.7 will give very nearly the corresponding dimensions in the scale of my enlargements. It follows that I and II correspond to a lunar chart having a diameter of 1.4 metres, which is nearly a mean between that of MÄDLER and that of SCHMIDT. Since on the latter $1^{mm} = 0''.95687 = 1.7832$ kilometres, it is seen that upon I and II $1^{mm} = 1''.367 = 2.547$ kilometres. A proof of this relation between linear and angular measure may likewise be deduced from the photographic focus of the Lick refractor. This taken at 570.2 inches = 14.48295 metres, will make the angle corresponding to one millimetre on the plate equal to 14.2419 seconds of arc, and increasing ten times, 1^{mm} becomes equal to $1''.4242$. We may therefore accept that $1^{mm} = 1''.4$.

In the following table the most notable objects upon I and II have been identified with SCHMIDT's map by taking off their position angles and distances. In order to enable one to compare the latter with each other, the dimensions from the SCHMIDT chart are multiplied by 0.7, those of I by $\frac{59}{61}$ and those of II by $\frac{59}{57}$, and the values so obtained have been noted as reduced distances. That which has been found at variance with SCHMIDT may be seen in the annotations to each object at the foot of the table.

In order to obviate any misunderstanding, however, something must be said regarding the lithographic reproduction, which has been carried out in five different shades. Although this method may represent the drawings in a general way, it must be said that in the matter of the blending and in the finer degrees of shading a true copy can not be obtained. The mechanical process of a five-fold imprint from five different stones, which was found requisite to produce the numerous soft gradations, is alone sufficient to cause many faults, not considering those to which the lithographer himself is liable in making five different drawings of the varying tones of the same copy. It may be remarked that on the first proof there were discovered about fifty errors to each picture, and that the second proof, after reducing the requirements as much as possible, still showed about twenty-five errors to each. It had to be acknowledged at last that this work, if it is to be fairly true to the original, lies beyond the capabilities of lithography.

For this reason these *Archimedean* views with other drawings have since been transmitted for heliographic reproduction. It is only after their publication in heliogravure, which will appear in the annals of the Lick as well as the Prague Observatory, that a fair judgment can be formed of the accuracy and truth of the originals, and of the care bestowed upon their production.

The individual objects are given in the following table:

TABLE OF OBJECTS.—ARCHIMEDES.

Quadrant.	Object Number.	Schmidt.		I.		II.		Sch.	I.	II.	GENERAL DESCRIPTION AND POSITION OF OBJECTS.
		p	*d*	*p*	*d*	*p*	*d*	Reduced *d*			
		°	mm.	°	mm.	°	mm.	mm.	mm.	mm.	
N. E.	1	7	43.5	6½	27.1	5	25.5	30.4	26.2	26.4	small crater northeasterly of mountain E.
	2	....	....	....	....	14–61	11–12	....	....	....	northeast wall on interior.
	3	....	....	70	12.0	.....	.....	....	11.8	....	inner boundary of N. E. wall.
S. E.	4	120	50.5	....	....	120	33.7	35.3	....	34.9	craterlike object east of crater A.
	5	129	41.8	129	30.5	129	28.5	29.3	29.5	29.5	crater A.
	6	....	....	....	....	132	17.1	....	....	17.7	craterlike object on S. E. wall.
	7	141	40.0	....	....	140	29.8	28.0	....	30.8	object southwesterly of crater A. Defect in Plate?
	8	156	20.5	156	14.7	156	14.4	14.3	14.2	14.9	southerly mountain crest on exterior.
	9	....	....	....	....	162	24.3	....	....	25.2	defect in plate?
	10	....	....	165	31.0	166	31.2	....	30.0	32.3	object in mountain mass south of *Archimedes.*
S. W.	11	....	....	183	32.0	183	30.7	....	31.0	31.8	object in the same mountain mass.
	12	210	50.0	....	..	.....	.....	35.0	....	..	rill χ, southwesterly of *Archimedes.*
	13	....	....	210–232	8	.....	.....	....	7.9	....	southwesterly wall on interior.
	14	....	....	235	5.1	.....	.....	....	4.9	....	bright spot in interior. Fault in plate.
	15	237	20.0	236	15.5	.....	.....	14.0	15.0	....	transverse cañon in S. W. wall.
	16	....	....	237	24.7	.....	.....	....	23.9	....	ridge southwest of *Archimedes.* Fault in plate?
	17	247	39.3	249	24.0	.....	.....	27.5	23.2	....	terraced declivity, west of *Archimedes.*
	18	....	....	250	17.6	.....	.....	....	17.0	....	yokelike connection between westerly wall on exterior and interior.
N. W.	19	273	37.0	....	..	277	21.0	25.9	....	21.7	annular ridge west of *Archimedes.*
	20	281	30.0	281	21.2	.....	.....	21.0	20.5	....	craterlike object on west outer wall.
	21	....	....	....	....	304	34.7	....	....	35.9	crater pit. Defect in plate?
	22	309	41.8	309	30.5	309	28.5	29.3	29.5	29.5	crater C.
	23	332	36.4	333	25.7	331	26.1	25.5	24.9	27.0	crater d.

Remarks.

1. This little crater, shown by SCHMIDT, northeast of the Mountain E, with a diameter of about 2.5 kilometres, appears bright on I (like crater *d*, northwest of E) and may perhaps be identical with the little dark speck in the given position on II. There is a better agreement of *p* and *d* in I than in II; it is necessary to observe that on account of libration the first distance is to be increased and the second decreased in order to obtain a reduction to mean libration.

2. The interior northeast wall shows in this area two extensive depressions on II, the northerly having a crater-like appearance; while SCHMIDT has this inner wall entirely separated from the outer, without showing any transverse yoke or saddle.

3. At this point we notice upon I a light finger-shaped appendage (buttress), of the extent of 1½^{mm}, by which the

inner wall projects into the floor of *Archimedes.* SCHMIDT has nothing similar.

4. This object, east of crater A, appears on II like a crater pit, and agrees with the most northerly of the small craters there depicted by SCHMIDT.

5. The northwest edge of crater A is not sharply defined upon II. While the diameter of this crater, measured normal to the line of the sun's direction, is nearly 4^{mm} on both I and II, this is no longer the case if measured in the direction of the sun, for in that case it becomes 4.7 (reduced 4.5) on I, and 5.2 (reduced 5.4^{mm}) on II, whereby an uncertainty in the position of the adopted initial point of the co-ordinates of 2.5^{mm} is caused.

6. On the southeast wall we have here according to II a nearly circular shallow depression of about $1\frac{1}{2}^{mm}$ diameter, which shows similar characteristics to the object described under (4). SCHMIDT has no indication of it, whereas the little crater shown on his chart on the southeast wall, with $p = 109°$, $d = 25.4^{mm}$, can not be recognized on II.

7. This object on II looks like a crater with a light floor, but it is possible that it may be a fault in the plate, for spots of similar extent, rotundity and intensity appear quite frequently upon the positive plate made at Prague, where their size amounts to 0.1^{mm} only, in places where such craters do not occur at all. It may be mentioned that this spot agrees pretty well with the end of the southwesterly valley joining on A as shown by SCHMIDT.

8. At this point the course of the outer crest line of the southwest wall agrees on I and II, but differs from SCHMIDT.

9. Appears to be a faulty little speck in plate II. SCHMIDT shows at this point no crater of any kind.

10. Here we notice upon II, in the mountain mass south of *Archimedes*, a depressed ellipitical plain of 4^{mm} extension, containing a central elevation. The position of the latter is designated by the given values of p and d. The same elevation is also found on I. The difference in d is fully explained by the effect of libration. This object, having all the *appearance* of a crater-like plateau on a high mountain range, not unlike the basin of a mountain lake, is shown neither by SCHMIDT, MÄDLER, LOHRMANN or NEISON.

11. This object looks on I like a crater formation, which it can not be, however, considering the shadow cast. It represents rather an elevation with an easterly shadow, as readily detected

upon II. Analogous illusions are apparent in several other objects of this plate, south of the one mentioned, but which have not been shown here.

12. Of this known rill nothing certain is recognized on I and II. The cause may lie in the conditions of exposure of the plates.

13. This part of the southwest wall shows on I very sharply notched configurations, which are not found on II. This may lead us to the conclusion, that these notches lie deeper than the crest, which is confirmed by SCHMIDT'S drawing of the southwest wall.

14. At this point we notice upon I in the interior of *Archimedes* a bright spot with an apparent easterly shadow. If this object of the plate has a real existence on the moon it would be a most interesting one, for MÄDLER ("The Moon"....) says: "We further remark that MAYER'S small chart of the moon has a bright spot in *Archimedes*, which seems to designate a central mountain. Such an one, however, is known with absolute certainty not to exist here. He probably saw the light central stripe very indistinctly and took it to be a central elevation." As we had no additional photographic plate of the same evening in Prague on hand, the decision of this question was left to Professor HOLDEN, who, after a most careful examination of the plates preserved at the Lick Observatory, expressed himself as against the real existence of this bright spot.

15. This transverse cañon in the southwest wall shown by SCHMIDT is clearly identified on I.

16. This position characterizes on I the centre of a bright ridge casting a shadow, situated southwesterly of *Archimedes*, extending about seven or eight kilometres nearly in the direction of the meridian, which object is entirely missing on SCHMIDT'S chart, for it indicates there a smooth plain. If this be not again a fault of the photographic plate similar to object 14 (which however is hardly probable), the reality of this ridge should become a particularly interesting fact. Nothing certain is discernible thereof on II.

17. This object seen upon I, the centre of which is located by *p* and *d*, makes the impression of a terraced declivity casting a shadow of about ten kilometres, west of *Archimedes*, and may be identical with the elevation shown by SCHMIDT, extending from northeast to southwest.

18. *At this point* will be noticed a yoke-like connection

between the exterior and interior walls of *Archimedes* in the west. At both sides of the same there are noticeable rifts or ravines of considerable depth. SCHMIDT has no indication of this.

19. Upon SCHMIDT'S chart this annular ridge is shown in the shape of a triangle. On I it is nearer like an oval lying in the direction of the meridian. Position angle and distance of the centres do not agree with sufficient accuracy.

20. This object seems to represent on I a crater-like depression but does not appear as such on SCHMIDT'S representation.

21. On II there is seen at this point something that looks like a sort of a crater-pit of small size, but this object is just as likely to be a defect in the photographic plate.

22. This crater designated by SCHMIDT as C shows upon I an elevated appendage or buttress on the east towards the mountain E, and on II it shows to the north and almost adjoining it a shallow pit. These are not given by SCHMIDT.

23. This crater which SCHMIDT refers to as *d*, appears on I as a bright spot, but upon II as a real crater. The difference in distance between I and II is accounted for by the effect of libration. It might be presumed, judging from the diverse character as indicated by the photographic plates, that only the eastern wall of this crater is of a precipitous nature; while the western wall has a more gentle decline, which would throw a deep easterly shadow only at a lower position of the sun.

Mountain E.—This is interesting on account of the difference in shape on I and II. From it a long ridge reaches toward the southwest, which does not, however, end off as uniformly as SCHMIDT has it. Particularly interesting is the dark crossing of the same, shown on both drawings east of the crater *d*.

Concerning the interior of *Archimedes* it is shown that both photographs do not at all lend it the appearance of the "mirror-like smoothness" of MÄDLER'S plain. In considering its numerous and diverse photographic details, it is of course to be observed that we are not able to separate those that are due to the inequalities of the bottom, from those that find their origin in faults of the plate and in the finer gradations of the sensitive film, so long as there are not at least two consecutively taken plates on hand for comparison. For this reason a discussion of the interior details of *Archimedes* must here be omitted entirely. It may only be mentioned that the well known lighter zones of the floor are quite visible, but that of the finer craters, shown by SCHMIDT and others, nothing is discernible in the interior.

The whole comparison of these photographic representations with SCHMIDT'S chart confirms again the excellence of the latter, but it shows too, that it may be improved upon.

It has also been of great interest to me to compare I and II under the same conditions of light with a view through the 6-inch STEINHEIL refractor of the Prague Observatory. II was compared on the 31st of March of this year, at 16½^h Prague mean time, I on April 17th, this year, at 8½^h Prague mean time with the celestial object. Although at both times the air was rather unsteady and not very clear, so that a magnifying power of only 150 seemed advisable, still it was readily proven to me that the photograph did not represent everything visible. For instance, clear and easily discernible tracings of terraces, on a brightly illuminated background were lost entirely, while in the lesser shaded parts a plentiful and just as easily distinguished detail was lacking altogether. It is possible to explain this only by assuming that the adopted mean period of exposure for the plate, which would furnish the best *average* picture, over-exposes the bright walls of *Archimedes*, and that thus the dark terrace lines thereon are obliterated, as a result of the effect of diffraction of the surrounding light, (compare the photographic representation of a narrow lightning-rod on a background of light clouds, which by exceeding a certain exposure will disappear entirely from the picture) and, on the other hand, shaded portions of the wall are under-exposed in the same manner. It must also be mentioned here that on the 17th of April of this year the crater *d* showed in its interior *another* shadow, whereas the same is entirely lacking on I. In addition to all this we must admit that numerous photographic details were *not* discernible with the telescope.

From the foregoing the conclusion is justified that photographic representations of the moon, as constantly improved upon and now approaching a degree of completeness never before attempted, as at the Lick Observatory, furnish a most valuable aid to optical observation, and will, considering the diversity in the chemical and optical *albedo* of the lunar surface, become the means of materially supplementing it. But it is to be remembered that *one* photograph alone will not give us an absolutely true representation of the moon, meaning a representation of *everything* visible; for with a certain period of exposure some parts will be sure to be over and others under-exposed. It is only by taking a series of consecutive photographs of varying exposures, which should be confined rather to very small lunar areas, that we can finally hope to obtain a copy true to nature. In the same manner in which we succeed in photographing the dark solar spots on the bright face of the sun, we should also be enabled to obtain the dark terraced lines on the lighter walls, heretofore referred to, or the fine black rills surrounded by bright light, if the exposure of the plate be properly reduced. The final decision in this matter, however, will depend upon experiment. Although a photographic representation of the moon, in spite of the most excellent results of the Lick Observatory, leaves much to be desired in point of strength and clearness, as particularly apparent in studying the greater enlargements, it yet furnishes us a wonderfully beautiful relief of considerable expanse, which can *never* be retained and depicted with equal truth to nature by the most skillful draughtsman, on account of the great mass of visible objects and the rapid change of lunar shadows; and at the same time it gives an astonishingly accurate detail of individual portions, which for the control and revision of present lunar charts becomes of the *utmost* value to the selenographer.

PRAGUE, July 6th, 1891.

NOTE TO PROF. WEINEK'S PAPER, BY EDWARD S. HOLDEN.

This is not the place to say how great an impulse has been given to the study of the moon by the investigations which Professor WEINEK has undertaken upon the Lick Observatory negatives. I desire, however, to say one word, in addition to what has already been said, upon the very important matter of reproducing the negatives, or drawings from the negatives, so that they can be published in large editions. This matter has engaged the attention of Professor WEINEK and myself for about two years. It is comparatively easy to find new features, and old features in new relations, upon our negatives of the moon; and it is easy to show these to any one who can study the original negatives or glass copies of them. It is, however, extremely difficult to reproduce the negatives in a large number of copies, so that any reader can follow a description. The most satisfactory method *theoretically* is to enlarge the original negatives by photography and to make silver prints from the enlarged negatives. This method has not been practicable for various reasons. It is very difficult, for example, to obtain 1000 silver prints from a professional photographer which shall all be satisfactory. We have therefore tried various photo-mechanical, lithographic and other means of reproducing either the original plates, or enlargements from them. A specimen of the most careful lithographic work is given in the present paper. The best phototype reproduction which I have been able to obtain is given in the *Century Magazine* for July, 1891. No one of these plates does justice to the original from which it was copied—neither to the original negative nor to Professor WEINEK'S exquisite drawings. And everything hitherto published must be regarded as tentative only.

We are, however, now in a position, to reproduce such originals in an adequate and entirely satisfactory manner.

Through the interest of Professor WEINEK and by the kindness of the Chief of the Imperial Institute of Military Geography, of Vienna, the Institute has consented to reproduce the drawings by *heliogravure.* Some specimens have already been received and they show conclusively that the question of reproducing such work is solved. It is hoped to go on with these studies of the moon as rapidly as possible through the co-operation of Professor WEINEK and the Lick Observatory.

MOUNT HAMILTON, October 1, 1891.

ESTRELLAS FUGACES, BÓLIDOS Y AEROLITOS, ESTUDIO POR EL DR. JESUS MUÑOZ TÉBAR, (Caracas, 1891, 8vo, pp. 27.)

[Abstract by the Author.]*

"An essay presented by the author to the Astronomical Society of the Pacific, as a membership contribution.

"The essay begins by a succinct historical description, which, brief as it is, touches every important point studied and meditated upon during the present century concerning shooting stars, bolides and aerolites, and eventually lands on the explanation of the present cometary theory.

"Then it goes on exposing the principal incidents which have been observed in connection with the appearance of said meteors, and presents a series of very grave objections against the present

* Dr. TÉBAR has printed in Caracas, under the date of August 25, 1891, a pamphlet in the Spanish language with the above title. On page 2 of the pamphlet is an abstract in English which is here reprinted.

theory, objections based upon those observations and upon several scientific principles.

"After some very interesting considerations on the subject and a number of remarkable quotations, it concludes by proposing an entirely new theory for the explanation of these phenomena.

"According to the author the shooting stars are ball lightnings which abound in the upper regions of the atmosphere and under certain conditions their number all over one and the same region is so considerable, as to present the appearance of a shower.

"When these lightnings are formed in the lower regions of the atmosphere or in the case of their descending far down in the same, they originate the so-called bolides; and when the ball lightning darts through a cloud or through air impregnated with substances lifted up from the surface of the soil and scattered in the atmosphere through cyclones and hurricanes or volcanic eruptions, their effect is to unite all those substances into one single mass, thus forming the meteorite or aerolite.

"Ball lightnings and rains of ball lightnings are not of frequent occurrence in the atmospheric strata immediately above the surface of the earth, still there are instances of both kinds of phenomena."

BESTIMMUNG VON PARALLAXEN DURCH REGISTRIR-BEOBACHTUNGEN AM MERIDIANKREISE, VON DR. J. C. KAPTEYN.

By Professor Lewis Boss.*

A more exact knowledge of the sun's motion in space is a pressing requirement in preparing the way for the stellar astronomy of the future. Up to the present time all our attempts to regard the stars in a comprehensive way, as situated in space of three dimensions, have been either rudely tentative, or merely speculative. To some extent this must continue to be the position of generalization in stellar astronomy for some time to come. Yet it is plain to be seen that stellar astronomy in its true geometrical relations is gradually advancing in importance with sure steps and continuously, toward the point when it must become the most fruitful as well as the most imposing object of research

* Director of the Dudley Observatory, Albany, New York.

in the entire range of science. One step in this advance has been the determination of the direction of solar motion, though no one has yet by any means exhausted the material upon this problem which is now actually available. A more important step will be a reasonably accurate determination of the velocity of the sun's motion in some known unit of length. Having accomplished this we shall have the base line for stellar investigation.

There are two important classes of astronomical measurements which, in connection with facts of which we already have sufficiently approximate knowledge, will lead to a satisfactory determination of the velocity of the sun relatively to some thousands of stars which are nearest it.

First, there are the spectroscopic measurements of the velocity of that component of the motion of individual stars which is in the direction of the line of sight, toward or from the sun. In this work the Greenwich Observatory has made a most important and praiseworthy beginning. Recently, Professor VOGEL, of the Potsdam Observatory, has shown that a very high degree of precision is attainable in this class of measurements. We are permitted to hope that his example will stimulate those who have powerful optical appliances at command to extend these measures so as to include, at least, all the stars visible to the unassisted eye which have motions of 10″ per century or more. When that is accomplished it is not at all improbable that we shall be able to determine the velocity of the sun's way, relatively to the stars considered, with greater precision than we now know the velocity of the earth in its orbit.*

This knowledge can be reached, however, in another way. If we take any large number of stars distributed over the celestial sphere it is possible to determine the angular velocity of the sun's way as seen from the mean distance of the stars considered; provided the ratio of the greatest to the least distance of the stars under treatment is not too large, or that the mean distances of groups of the selected stars in different quarters of the sky do not greatly vary, or, still better, provided we have some well-grounded criterion by which to judge of the relative distances of the stars considered. At present it might be regarded a hopeless task to accumulate satisfactory measures of the individual distances of the thousands of stars which ought to be taken into account in a re-

* I understand that the great telescope of the Lick Observatory is to be devoted to this research in the immediate future.

search of this kind. It happens that we are actually in possession of a very plausible hypothesis as to the proper criterion of judging relative distances of stars. This criterion consists simply in the supposition that in the mean of a large number of stars the distances are inversely proportional to the apparent thwart motions of the stars—the proper motions. Thus we are fairly entitled to say as the result of mathematical investigations that the stars having apparent proper motions of 10″ per century are four times as far from the sun as are the stars which have a proper motion of 40″. Professor T. H. SAFFORD was one of the first to call attention to this fact by specific calculations in a paper published seventeen years ago in Proceedings of the American Academy of Sciences (Vol. X, p. 82 ff). His conclusion that in studying the solar motion the distances must be assumed as inversely proportional to the proper motions has been substantially confirmed, although it is not known that the evidence has been collected in a systematic form,—evidence which may easily be gathered from the most important researches upon the motion of the sun that have appeared during the last twenty years. It is indeed probable that this criterion of distance may ultimately require some modification. It already appears probable that the stars with the larger proper motions are relatively nearer the sun than is indicated by the law of inverse ratio of proper motion. Thus it might be inferred that the sun is situated in a cluster of small stars slightly and gradually condensed toward the center. Still other modifications of this law are indicated,—but too uncertainly for profitable comment at the present time.

Evidently when stars are considered in classes of brightness involving thousands in each class, there may be a rough correspondence of distance with apparent brightness. There would also be a rough correspondence in the average of proper motions, such that the brighter stars, in the mean of a very large number, would have larger proper motions. It appears inadvisable, therefore, to introduce a factor representing the feeble testimony of brightness as to distance into the criterion for relative distances of the stars.

It should by borne in mind that on the hypothesis that the directions of stellar motion are equally distributed (at random) over the surface of the sphere we see on an average nearly four-fifths ($\frac{\pi}{4}$) of the total motion; and not quite 14 per cent. of the stars would exhibit less than one-half the total motion.

It becomes evident, therefore, that a fair degree of approximation as to the real distances of stars considered in large groups may be derived from the measurement of a comparatively small number of parallaxes. At the same time, if these measurements are distributed over the widest practicable range of proper motion we may derive additional testimony of some value as to whether the inverse ratio of proper motion affords in the mean a safe criterion of relative distance. For this purpose one would select, say, five hundred stars having proper motion greater than 25″ per century. If, then, it were found, for example, that the average annual parallax is one-tenth of the proper motion, we should possess a ready means of assigning with some degree of confidence the mean distance of any large number of selected stars having nearly the same apparent proper motions. It is this far-reaching application of our knowledge of annual stellar parallax in individual cases that should stimulate interest in the determination far beyond that which would attach to the problem in its direct relations.

Prof. Dr. KAPETYN has shown in what way a large number of observers, already in possession of the requisite instrumental equipment, may produce important contributions in the interest of these stellar problems which in the foregoing paragraphs have been merely indicated in their surface relations. The method for determination of parallax adopted by Professor KAPTEYN has not only the very great advantage in a problem of such delicacy as this of variation in method, but it also appears to have produced highly trustworthy results at a comparatively small expenditure of labor. He has determined the parallaxes of fifteen stars selected from ARGELANDER'S well known list of two hundred and fifty stars of large proper motion (*Bonner Beob.*, *Bd.* VII, *Theil* I). For this purpose he used his vacation time and employed the meridian circle of the Leyden Observatory. The adopted method was to determine differential parallaxes by means of differential transits near the two extremes of parallactic displacement in Right ascension.

The method of differential transits had been tried in the practiced hands of Dr. AUWERS with the Equatorial of the Gotha Observatory in the years 1863-1866, and the result was not such as to encourage its further employment. But the parallaxes which Dr. BELOPOLSKY had deduced from the transit observations of WAGNER afforded evidence that the use of meridian transits for this research is full of promise. The observations of WAGNER were not intended to be used for this purpose, and there was, therefore, no systematic arrangement of comparison stars. The probable errors were in consequence large; yet the results seemed to indicate that this method is remarkably free from sources of constant error,—a conclusion which the observations of Professor KAPTEYN appear to have confirmed in a remarkable degree.

The arrangement of Professor KAPTEYN's observations was quite simple. It consisted in selecting two comparison stars of small proper motion (and presumably of small annual parallax), and arranging this selection in such a way that the mean of the declinations of the comparison stars would fall very near that of the star whose parallax was to be determined. Since the interval in declination between the two comparison stars in each case was also small, the requirement was practically reduced to a question of well made pivots, kept thoroughly clean, with careful handling of the instrument, and the greatest attainable perfection in the registry of transits. The actual positions of the stars and the exact value of the instrumental constants, thus became considerations of minor importance. In order to eliminate the possibly injurious influence of imperfectly determined proper motions, the series of observations were arranged so as to begin and end at the same season. The epochs of observation were: 1885 April, 1885 December, 1886 December, and 1887 April.

The most troublesome source of systematic error to be feared arises from possible variation of the personal habit of registry as between stars of different degrees of brightness. Evidently, if this personal error of the observer remains constant throughout the series, no appreciable error could arise from this source. But this constancy of habit could by no means be assumed, and probably does not obtain with the great majority of observers. Professor KAPTEYN employed wire-gauze screens in front of the objective not only for the purpose of reducing the images of parallax and comparison star to nearer equality of brightness, but also to determine the personal equation for magnitude at the several epochs of observation. The outcome of this part of the investigation was that in the first period the faint stars were observed too late by $0^s.0005$ for one magnitude; in the second series, too early by $0^s.0042$; in the third, too early by $0^s.0068$; and in the fourth, too early by $0^s.0045$ for each magnitude. Professor KAPTEYN concludes that whatever change there may have been, took place between the first and second series. He had been out of practice in transit observations for seven years previous to this undertaking, and it is natural to suppose that his personal habit of observing transits might have been a little uncertain at first. At any rate, it appears that the assumption that his personal error remained invariable throughout the series would not have made a difference of more than 0″.01 in the deduced parallax in any case.

The probable error of transit for a single thread was found to be only ± $0^s.0404$, and the actual probable error of a comparison depending on about twenty threads for each star came out ± $0^s.0168$, or ± $0^s.0158$ by the use of weights,—leaving less than ± $0^s.01$ for the "day-error," or general instrumental error. None but the most careful and skilled observers can hope to attain these low limits of error.

The tables of detailed reductions for each comparison star bear ample testimony to the care and thoroughness with which the computations have been made. In a research in which the final quantity to be ascertained is very nearly, and in many cases quite, of the order of the probable error, only the most rigorous computations serve to bring out the value of good observations.

The following table contains a summary of Professor KAPTEYN'S results:

Star.	Parallax.	P. E.	Proper Motion.
	″	″	″
Arg. 81 pr.	+ 0.074	± 0.027	1.69
θ Urs. Maj.	+ 0.052	± 0.026	1.11
Arg. 85	+ 0.064	± 0.022	0.79
20 Leon. Min.	+ 0.062	± 0.029	0.69
Arg. 89	+ 0.176	± 0.024	1.43
Arg. 94	+ 0.101	± 0.026	0.89
Arg. 95	+ 0.038	± 0.027	0.27
Lal. 20670	— 0.011	± 0.029	0.30
Arg. 104	+ 0.428	± 0.030	4.75
Arg. 105	+ 0.168	± 0.027	4.40
Arg. 110 sq.	+ 0.030	± 0.027	0.64
Arg. 111	+ 0.016	± 0.032	0.67
Groomb. 1830	+ 0.139	± 0.026	7.05
Arg. 114	— 0.038	± 0.042	0.69
Arg. 119	+ 0.056	± 0.034	0.33

While Professor KAPTEYN contends that with the same expenditure of labor one may attain to nearly as small a probable error by this method of differential transits as by the use of the heliometer, he also concedes in his closing remarks that this method is best adapted to the investigation of parallax by the wholesale, rather than to that of individual parallaxes. He outlines a very attractive program whereby a few observers, in a comparatively short time, would be able to determine the parallaxes of all the stars of the fifth magnitude or brighter. According to the Uranometria Argentina these, including both hemispheres, number 1212. Assuming that, at the two extremes of parallax in Right Ascension, it is possible on the average to secure an available factor of 0.89 in the observations (measuring 1.76π in each case), eight observations at each extreme would give for the probable error of each parallax, $\pm$ 0″.052. All parallaxes of 0″.20 or greater would be certainly detected; 90 per cent. of those greater than 0″.15 would be revealed; and of those which come out by observation 0″.10 or more, three-fourths would turn out to have parallaxes of 0″.10 or greater. But, as he maintains, the important result would be that the *mean parallax* of each class (order of magnitude) would be determined with great exactness.

There seems to be nothing unreasonable, or unattainable, in the enthusiastic picture which Professor KAPTEYN presents. In the present state of stellar astronomy, it might be suggested that the stars for such a *Parallax-Durchmusterung* ought not to be selected according to their magnitudes, but according to their proper motions. Let the 1000 stars having largest proper motions be selected for this proposed investigation. If such an investigation were carried on with the vigor and skill which is manifest in the work of Professor KAPTEYN here under consideration by four observers, two in each hemisphere, there is scarcely a doubt but that the necessary observations could be completed on a liberal scale within from six to ten years, and that the results would be of inestimable value in founding the stellar astronomy of the future.

In selecting these stars having large proper motions, it might be well to leave out all those of the fifth magnitude or brighter. These would be but a small fraction of the whole; and there is not much doubt that more reliable results for these brighter stars would be attainable by the use of the heliometer. The stars fainter than the ninth magnitude should be attended to by photography. In selecting the comparison stars for use with the parallax stars, care should be exercised, so far as possible, to employ no stars for comparison that have a sensible proper motion. Furthermore, the magnitudes of the comparison stars should be as nearly as possible the same as those of the respective parallax stars. For stars below the 6.5 magnitude these conditions would not be difficult of attainment; for brighter stars the difficulty would increase very rapidly with the magnitude, and this constitutes sufficient reason for turning those stars over to the heliometers. With such an arrangement of comparison stars and with no observing appliances further than those which are already available, we appear to have the means of attacking the general problem of star-parallax more effectively than ever before. It would be difficult to conceive of a method which offers better security against the influence of systematic error.

The work of Professor KAPTEYN well illustrates the possibility of putting new life into a hackneyed subject without the aid of startling novelties either in the details of methods, or in the apparatus employed.

OBSERVATIONS OF THE DARK TRANSIT OF *JUPITER'S* THIRD SATELLITE ON AUGUST 20, 1891, AT WINDSOR, NEW SOUTH WALES.

By JOHN TEBBUTT, F. R. A. S.

The times of the various phases are local sidereal.

h.	m.	s.	
18	33	34;	the satellite had advanced considerably on the disc of its primary and was visible as an oval dark spot on the north edge of one of the slender belts in the south equatorial zone. The major axis of the oval was parallel to the belt. The satellite was not nearly so dark as its shadow, which was also visible.
18	50	59;	satellite still visible.
19	24	59;	it was now at about mid-transit, and the dark phase had slightly increased in depth.
20	3	59;	the preceding observations were made with the 4½-inch equatorial and a power of 120. I was now enabled to turn the 8-inch telescope on the planet, and with a

h. m. s.

power of 74, found the satellite to be quite conspicuous as a dark spot.

The following measures were made of the satellite's position on the disc by turning the distance-threads of the micrometer parallel to the belts, and placing one on the satellite and the other alternately across each pole of the planet.

20 11 54; distance from south pole = 12″.23 (3 measures).
20 13 14; distance from north pole = 34″.63 (3 measures).
20 21 59; satellite had obviously faded.
20 25 59; still plain, but fainter.
20 29 49; much fainter.
20 32 9; very indistinct.
20 33 34; seen with great difficulty.
20 34 59; not certainly visible.
20 47 59; satellite had been suspected for some time, and was now certainly seen as a faint bright spot just within the limb with powers 74 and 112.
20 50 39; distinctly seen as a bright spot with a power of 112 at internal contact.
20 54 44; bisection.
20 58 59; external contact.

Clouds prevented observation of the transit of the 27th of the same month.

WINDSOR, N. S. WALES, Sept. 4, 1891.

(SEVENTH) AWARD OF THE DONOHOE COMET MEDAL.

The Comet Medal of the Astronomical Society of the Pacific has been awarded to E. E. BARNARD, Astronomer of the Lick Observatory, for his discovery of a Comet at 0^h 55^m G. M. T., October 3, 1891. This is the nineteenth comet discovered by Mr. BARNARD.

The Committee on the Comet Medal,

EDWARD S. HOLDEN,
J. M. SCHAEBERLE,
CHARLES BURCKHALTER.

(Dated) October 12, 1891.

THE FORMS OF *JUPITER'S* SATELLITES.

By J. M. Schaeberle and W. W. Campbell.

While we were engaged in observing the markings on the third satellite of *Jupiter* with the 36-inch equatorial, in 1891, August, September and October, we noticed that the first satellite was not round. Careful observations of all the satellites on several nights have led us to conclude that the first satellite of *Jupiter* is ellipsoidal, that its longest axis is directed towards the centre of *Jupiter*, and that the other satellites appear to be spherical. (See *Astronomical Journal*, no. 247.) The results of the observations on the several nights are given below.

1891, Sept. 6. Seeing very fine. [The spiral or double-ring structure of the nebula in *Draco*, G. C. 4373, shown beautifully under all powers up to 3000.] While waiting for eclipse (reappearance) of satellite III, it was seen that I was elongated in the position angle 70°–250°, in the ratio 5:4. I, II and IV were successively brought to the same collimation axis without changing the focus, using all powers up to 3000, but 2000 was used to best advantage. I was decidedly elliptical under all tests; II and IV were round. After the reappearance of III, the observations were repeated: I elongated; II, III and IV round.

At the extremities of the major axis of I were bright regions which probably caused a part of the apparent elongation, but cannot account for it all. Later, it was noticed that the position angle 70°–250° was equivalent to the longer axis pointing towards *Jupiter's* centre.

1891, Sept. 16. Seeing, weight 3.

The highest power used was 1000. I was decidedly elongated, probably 5:4, in a direction parallel to *Jupiter's* equator, the end towards *Jupiter* being very bright. II appeared very slightly elongated in position angle 45°–225° with reference to *Jupiter's* polar axis, probably owing to the very bright region at the southern end of the major axis. III was round, but a very bright region on the northeast limb gave it the appearance of being elongated, when the seeing was poor, in the direction 30°–210° with reference to *Jupiter's* polar axis. This probably accounts for SECCHI'S observed ellipticity of this satellite (see *Astr. Nach.*, no. 1017, pp. 135–142). IV was round; the end towards *Jupiter* bright.

1891, Sept. 20. Seeing, weight 2.

While I was in transit, near egress, it appeared round, or very nearly so. Its shadow was likewise round or only very slightly elongated the whole time. Powers greater than 700 could not be used on account of poor seeing. After the egress of I it was certainly elongated, though not so much as had been observed before, and there were bright regions at its preceding and follow-ends. II was either round or elongated only very slightly as before. III and IV were round.

1891, Sept. 26. Seeing, weight 4.

I was certainly elongated in direction of *Jupiter's* equator, but less than when it was observed near quadrature. The bright regions on I were not at all prominent. II was either perfectly round, or very slightly elongated nearly at right angles to *Jupiter's* equator. III and IV were round. The northeast polar cap on III was scarcely visible. Powers 700 and 1000. [W. W. C. alone.]

1891, Sept. 27. Seeing, weight 3.

Before and after transit, I was certainly elongated, apparently not so much as when seen near quadrature. During the visible part of its transit it was continually elongated in the direction of *Jupiter's* equator. When nearest the centre, it was almost round. At $10^h 27^m$ P. s. t., just before egress, it was elongated 2:1, and two condensations of light in it gave it the appearance of being double. The shadow of I was elongated 3:2 just after ingress, and when nearest the centre was only very slightly elongated. II was very slightly elongated nearly at right angles to *Jupiter's* equator. III and IV were round.

1891, Oct. 4. Seeing, weight 3.

Before and after the transit of I, it was certainly elongated. During the transit the elongations of I and its shadow varied from 1½:1 or even 1¾:1, just after ingress, to nearly round when they were nearest the centre. II appeared elongated nearly 5:4 in the direction 15°–195° with reference to *Jupiter's* polar axis, but a very bright region was observed at its southern extremity. III and IV were round.

1891, Oct. 17. Seeing, weights 3 and 4.

When the seeing was best, I was elongated; its equatorial regions were fairly bright. II was practically round, bright southern region. III and IV were round. The southeast limb of III was bright. [W. W. C. alone.]

1891, Oct. 18. Seeing, weight 2.

I very noticeably elongated; the equatorial extremities were bright. II was very slightly elongated, the south limb was very bright, and the north limb was bright. III round, but in poor seeing it appeared elongated in direction 25°–205° with refence to *Jupiter's* axis, probably owing to its bright southeast limb. IV was round. [W. W. C. alone.]

1891, Oct. 23. Seeing, weights 3 and 4.

Satellite I clearly elongated in good seeing, power 1000, the preceding and following limbs very bright. II apparently elongated at times in position angle 30° with reference to *Jupiter's* axis, but perfectly round in best seeing. III apparently elongated in position angle 35° with reference to *Jupiter's* axis, owing to very bright northeast limb and bright southwest limb, but perfectly round in best seeing. IV round. Shadow of IV nearly round, with penumbra. [W. W. C. alone.]

1891, Oct. 24. Seeing, weights 2, 3 and 4.

I elongated 5:4. II in transit near egress, round; its shadow slightly elongated in *Jupiter's* equator, with penumbra. III and IV round. [W. W. C. alone.]

It is evident from these observations that the apparent forms of the satellites are largely affected by the bright regions on portions of their limbs, especially when the seeing is poor. Taking everything into consideration we are convinced that Satellite I is actually elongated in a direction nearly parallel to *Jupiter's* equator, the ratio of the axes lying between 10:9 and 5:4, probably very near the last limit; and that the other satellites are practically round.

The elongation of I confirms the view, afforded by some photometric measurements, that its periods of rotation and revolution are equal. Other things being equal, the maximum bright ness due to the ellipsoidal form would occur when the satellite is in quadrature.

From the observations of I and its shadow during transits given above (see also *Publ.* A. S. P., no. 17: p. 265, J. E. K.; p. 267, J. M. S.; p. 268, E. S. H.; p. 269, E. S. H. Also, *Astr. Nach.*, nos. 2995 and 3051, E. E. B.), it is plain that various phenomena can be expected. This is probably due to the great variety of backgrounds which *Jupiter's* surface affords; to the effect of *Jupiter's* atmosphere; and, possibly, to that of the satellite.

PATH OF A SHOOTING STAR.

By Torvald Köhl.

Among the corresponding observations on Perseïds made in Denmark this year there is one of special interest to which I beg to direct attention. The meteor appeared on the 11th of August at $10^h\ 34^m\ 29^s$ (mean time of Copenhagen) and was observed in *Copenhagen* and also in *Odder*, situated in 2° 25′ w. long. from Copenhagen, 55° 58′ n. lat.

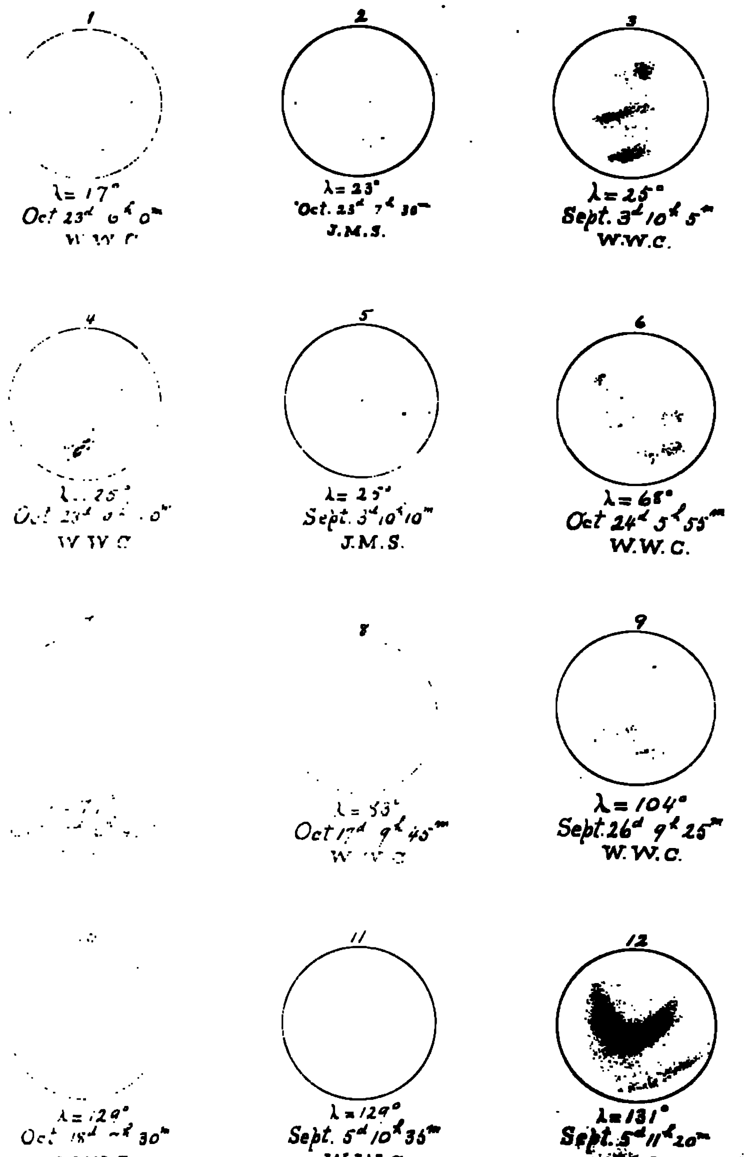
The lines drawn through the beginning and the end-points of the apparent path almost exactly touched the position [17°, 6° 40′] where the eastern station (Copenhagen) was to be seen from the western (Odder), and with corrected positions

	Beginning.	End.
Odder	312° + 29°	290° + 14°
Copenhagen	234° + 26°	236° + 12°

The computation was made in two different ways, which gave the following results:

Method.	Beginning.			End.		
	h	λ	ϕ	h	λ	ϕ
Construction . .	95	2° 0′w.	55° 34′n.	90	2° 36′w.	55° 15′n.
Calculation . . .	95	2° 0′w.	55° 34′n.	93	2° 36′w.	55° 14′n.

The shooting star appeared in a height of 95 kilometers above the northern coast of the Danish island Fyn and disappeared 91.5 kilometers above a place near Assens on the same Island. In about one second this meteor had passed 52 kilometers away,



JUPITER'S THIRD SATELLITE

and from its high place an observer might have seen more than 1000 kilometers round in all directions and would have overlooked a great part of Norway, Sweden, Russia, Germany, France, England and Scotland besides the whole of Denmark, Holland and Belgium.

THE REAL SCHOOL, ODDER, DENMARK,
1891, September 30.

OBSERVATIONS OF MARKINGS ON *JUPITER'S* THIRD SATELLITE.

BY J. M. SCHAEBERLE AND W. W. CAMPBELL.

Great interest has been shown by astronomers ever since the early days of the telescope in the question of the rotation periods of the satellites. The fact that our moon rotates on its axis once in a revolution about the earth has encouraged investigations to determine whether the law holds with the other satellites of the solar system.

As early as 1665, CASSINI * observed that when the satellites of *Jupiter* were in transit across the face of the planet, "he could see markings in exactly the positions where he knew the satellites to be, which proved that the markings were on the satellites themselves." Since these markings could not always be seen he inferred that the satellites rotated on their axis, but published no estimate of their periods. We now know that any attempt to see these markings by means of such rude telescopes as were at CASSINI'S disposal would prove futile.

Sir WILLIAM HERSCHEL † noticed that considerable changes occurred in the brightness of the satellites. During the years 1794-5-6 he made a number of estimates of their brightness when they were in different parts of their orbits, and found that the periodic variations of brightness were explained best by the theory that they rotate on their axes once in a revolution.

In 1796 SCHROETER‡ saw a dark marking on satellite III on three nights when the satellite was in the same part of its orbit,

* Director of the Paris Observatory. See *Histoire de l'Académie Royale des Sciences.* Tom. I, pp. 265-266.

† See *Philosophical Transactions*, Vol. 18, pp. 187-196.

‡ See *Astronomisches Jahrbuch:* 1800, pp. 169-170; 1801, p. 126.

and a marking on IV on two nights. A year later he wrote: "We have repeatedly seen dark spots on all the four satellites, even the two smallest, the first and second, with absolute certainty." From his observations he was led to conclude that "all the satellites without exception certainly rotate on their axis once in a revolution." However, the acute observer HERSCHEL observing at the same time "with abundant light and high powers," with the special purpose "to examine the nature and construction of the bodies of the satellites themselves," makes no mention of any markings.

On three occasions, in 1849 and 1860, DAWES* observed dark markings on the third satellite when it was in transit. His drawings agree remarkably well, and "render it probable that the same aspect of the satellite was turned toward the earth on all these occasions. But a larger number of observations was necessary in order to decide upon the rotation period.

SECCHI,† in 1855, observed several markings on III, from which he concluded that the satellite rotated on its axis in a very few hours. He says: "The difficulty of these observations is extreme; they require a very tranquil atmosphere, which is rare in this warm country [Rome]."

Photometric observations of the satellites by AUWERS and ENGLEMANN to some extent confirm HERSCHEL's results. But ENGLEMANN,‡ after reviewing all the known observations of III, both photometric and topographical, concludes that the observations are not yet sufficiently numerous and reliable to fix the rotation period of III.

Still later, in 1877–8, PICKERING§ measured the brightness of the satellites with great accuracy, and found no evidence of variability. He says: "It has been thought by many astronomers that the light of the satellites of *Jupiter* is variable. This view is not sustained by the present measurements."

The foregoing *résumé* is necessarily incomplete. Many of the observations omitted are of great interest, but, on the whole, they confirm the view that the question of the rotation periods of the satellites is still an open one.

The seeing at Mt. Hamilton on the night of August 24, 1891,

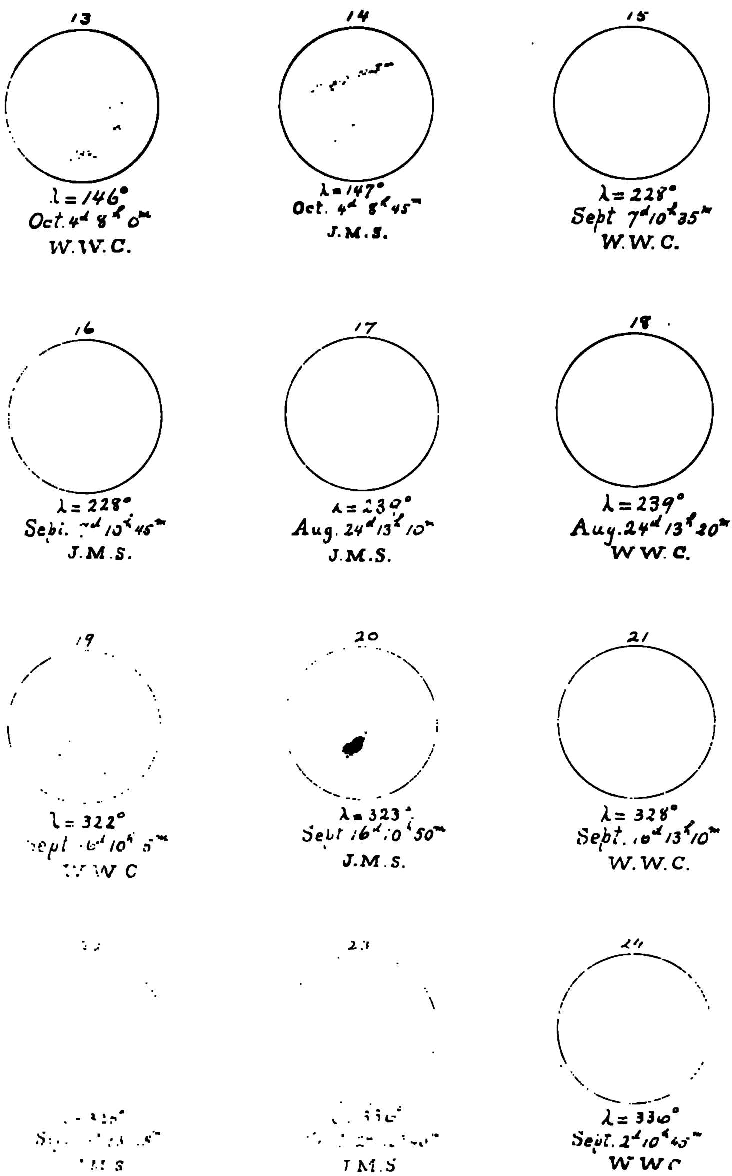
---

* See *Monthly Notices*, vol. XX, pp. 245–6.

† See *Astronomische Nachrichten*, no. 1017.

‡ See his *Ueber die Helligkeitsverhältnisse der Jupiterstrabanten*.

§ See *Annals Harvard Coll. Obs.*, vol. 11, p. 245.



JUPITER'S THIRD SATELLITE.

appearing to be unusually fine, the spectroscope attached to the 36-inch refractor was removed and the telescope directed to *Jupiter*. The seeing was perfect.

The surface of the planet was a mass of details, which could not be drawn in days. Turning to Satellite III, with a power of 2000, it was seen to be perfectly round. Some dark markings on its surface showed so plainly and certainly, that we independently made drawings of them. Two dark belts were well defined, as was also a lighter region between them. The northern polar region was much brighter than any other part of the surface. These markings remained practically unchanged under all powers from 700 to 2000 and for various positions of the eyes.

These drawings are reproduced in numbers 17 and 18 of the accompanying illustrations, together with those made later. All the drawings are arranged in the order of the positions of the satellite in its orbit, letting $\lambda = 0$ when the satellite is at inferior conjunction with respect to the earth. The recorded times are Pacific standard times. Horizontal lines on the drawings would represent the direction of *Jupiter's* equator.

Further observations of III are given below.

September 2, 3 and 5. Seeing, weight 2. Power 700. The drawings 23, 24, 3, 5, 11 and 12 made on these nights are of small weight. The north polar region was bright each night.

September 6. Seeing very fine. $\lambda = 184°–186°$. The eclipse (reappearance of III) was observed with power 2000. The satellite occupied ten minutes in passing out of the shadow. In this interval its visible disk passed through all the phases from a thin segment to a full circle. The edge nearest to *Jupiter* was always fainter than the other edge, and the dividing lines between the umbra, penumbra and the fully illuminated portions were sharply defined. We were unable to see any markings on III.

September 7. Seeing, weight 2. Power 700. Markings difficult, north polar region bright. Drawings 15 and 16.

September 16. Seeing, weights 4 and 3. Powers 1000 and 700. The satellite was observed occasionally in the interval of three hours between the first and last drawings. The markings did not change appreciably, except to become more difficult. North polar region very bright. Drawings 19, 20, 21 and 22.

September 20. Seeing, weight 2. $\lambda = 160°–165°$. No markings visible.

September 26. Seeing, weight 4. Power 1000. The markings were quite distinct. The north polar region not so bright as usual. [W. W. C. alone.] Drawing 9.

September 27. Seeing, weight 3. $\lambda = 155°–160°$. No markings visible.

October 4. Seeing, weight 3. Power 700. Markings difficult, north polar region not so bright as usual. Drawings 13 and 14.

October 17. For drawing no. 7: seeing, weight 4. Powers 700 and 1000. Markings easy, north polar region bright. For drawing no. 8: seeing, weight 3. Power 700. Markings more difficult. [W. W. C. alone.]

October 18. Seeing, weight 2. Power 700. Markings very difficult and drawing of small weight. Both polar regions bright. Drawing 10. [W. W. C. alone.]

October 23. For drawing 1: seeing, weight 4. Powers 700 and 1000. Markings easy, and vertical channel in middle and south belts certainly seen. North polar region very bright, south polar region bright. [W. W. C.] For drawing 2: seeing, weight 2. Power 700. Markings difficult, north polar region very bright. [J. M. S.] For drawing 4: seeing, weights 3 and 4. Power 700. Markings easy, polar regions bright. I feel sure the markings have not changed appreciably in the interval of $3^h\ 20^m$. [W. W. C.] At $11^h\ 50^m$, seeing too poor to see markings.

October 24. Seeing, weight 3. Power 700. The markings easily seen, and during an interval of 2½ hours they did not change appreciably. The north polar region bright. Drawing 6. [W. W. C. alone.]

October 26. Seeing, weight 3. $\lambda = 172°–177°$. Image steady. The surface apparently uniform, except the perimeter was bright by contrast.

Until this series of observations was completed we purposely avoided looking up the work of previous observers. We were not acquainted with the drawings of DAWES, SECCHI and others, nor with the details of the photometric observations of HERSCHEL, AUWERS, ENGELMANN and PICKERING. We likewise avoided making a study of our own drawings to see if they supported any theory. Moreover, each of us made his drawings independently of the other; several eye-pieces were generally used before a drawing was finished; the satellite was observed with the eyes in different positions; and the position angle of *Jupiter's* equator was indicated on the drawings every night except the first. In spite of all these precautions the drawings are probably not free from personal errors.

For values of λ between 147° and 228°, that is when the satellite was in the part of its orbit furthest from the earth, we were unable to see markings clearly enough to draw them, although on four evenings [September 6, 20, 27; October 26] attempts were made to do so. It is probable that the markings on the hemispheres presented to us at those times were actually fainter than those seen at other parts of the orbit. Failure to see them could hardly be due to the nearness of the bright planet, for the markings when the satellite was nearly between the earth and *Jupiter* were apparently not affected by the proximity of the planet.

It is apparent from the drawings that the satellite is in general crossed by three dark belts, more or less broken, of which the upper (south) belt is the faintest. The estimated position angles of the belts (with reference to *Jupiter's* equator) vary from 15° to 40°, the average being about 30°. If the satellite has a motion of rotation, the persistency of the belts shows that the axis of rotation made at this time an *apparent* angle of about 30° with the axis of *Jupiter*. This is confirmed to some extent by the fact that the bright north polar cap was situated symmetrically with respect to the north belt (whose north edge it sharpens greatly by contrast).

That the period of rotation is a long one, follows from the observations of September 16 and October 23, when the satellite was observed for several hours without apparent motion of the markings. In no case was any motion observed in the course of an evening's observations.

With very few exceptions a comparison of the individual drawings shows that the satellite rotates on its axis once in a revolution around the planet, and therefore, like our moon, always presents the same face to its planet. This theory represents the observations much better than any other. The apparent exceptions can, for the most part, be attributed to poor seeing, and are, in fact, only such as must be expected in all observations of very delicate shadings of this kind. The angular diameter of the satellite, as seen from the earth, was always less than 2″; and in drawing the small and faint markings which are only a few tenths of a second of arc in size, it could not be expected that different observers would agree exactly in the minor details. It might seem at first sight, for example, that the drawings 17 and

18, made under the most favorable circumstances, differ very materially from each other. Yet such is not the case. If the drawing 17 be placed upon 18 it will be found that the dark and light portions of the one sensibly coincide with those of the other, and that the difference is one of detail. The same is true of the apparently dissimilar drawings 21 and 22. Though several of the drawings are entitled to small weight on account of poor seeing, it appears that those made on the same evening agree well with each other.

The vertical channels in the upper (south) belt do not support the theory of equal rotation and revolution periods unless there are at least four such channels. This is probably the case. The channel in drawings 1 and 4 was plainly seen, and apparently did not move in an interval of $3^h\ 20^m$. Those drawn in 6 and 7 were difficult and somewhat uncertain. The channel in 17 and 18 was easy. The one in 19, 20, 21 and 22 was plainly visible and did not move during the interval of $3^h\ 10^m$.

The manner in which the dark markings terminate before reaching the edge of the disk suggests the presence of an atmospere on the satellite. For, although the contrast due to the dark background of the sky tends to obliterate the markings near the limb, yet it can hardly account for the uniform brightness of the perimeter (excepting, of course, the bright south pole and the very bright north pole).

In the present unfavorable (far south) position of *Jupiter*, we are unable to see any definite markings on satellites I and II, except the bright regions on their limbs referred to in the preceding paper. But very accordant drawings of satellite IV, made by us on September 16, promise well for the determination of its rotation period by the same method when, in three or four years, *Jupiter* attains its greatest northern declination.

None of the observations were made with powers less than 700. With lower powers we found it difficult to distinguish between a real marking and an apparent one caused entirely by contrast. Indeed, it is not improbable that the existence of some of the markings on satellites I and II reported by observers using low powers is doubtful for this reason.

An observation of satellite III with the 36-inch equatorial, on Aug. 17, 1890 [by E. S. H. and W. W. C., see *Publ.* A. S. P., vol. III, p. 272], showed a dark marking which in the interval of $1^h\ 45^m$ appeared to move perceptibly, thus indicating a short rotation period for the satellite. It was then in the position $\lambda = 285°$, a part of the orbit to which none of our drawings correspond. The sketches made then locate the marking in the heavy central and lower belts of the drawings 18, 19, 20, 21 and 22. The seeing was average; but it is possible that the low powers used—360 and 520—together with any change in the seeing in the interval of 1¾ hours between the sketches, would account for the apparent change of position of the markings. So far as this observation goes it is opposed to the theory of equal rotation and revolution periods, but neither of the observers of that night is disposed to lay any very great weight upon it.

While the foregoing observations do not definitely decide the question of the rotation period of the third satellite, yet they very strongly support the theory that the satellite rotates on its axis once in a revolution about the planet.

The same conclusion with respect to the *first* satellite follows from our observations of this year. (See *Publications* A. S. P., vol. III, p. 357.)

[The satellites of *Jupiter* were frequently examined during the oppositions of 1889 and 1890 and all the observers were satisfied that markings existed on some of them. The planet was, however, unfavorably situated as to altitude, so that no observations of special importance were made in those years.]

FRANCIS BRUENNOW.
1821–1891.

NOTICES FROM THE LICK OBSERVATORY.

PREPARED BY MEMBERS OF THE STAFF.

FRANZ FRIEDRICH ERNST BRÜNNOW. BY PROF. A. KRUEGER.*

FRANZ FRIEDRICH ERNST BRÜNNOW, the eminent astronomer, departed this life on August 20, 1891, in Heidelberg, at the age of nearly seventy years. He was born in Berlin on the 18th of November, 1821, his mother (née WILHELMINE WEPPLER) being the first wife of JOHANN BRÜNNOW, Privy Counselor at the Royal Court. He attended the Friedrich-Wilhelm Gymnasium from 1829 to 1839, when he entered the Berlin University, attending the lectures of DIRKSEN, LEJEUNE-DIRICHLET, OHM and STEINER in Mathematics, ENCKE in Astronomy, and DOVE in Physics. He also listened to the lectures of the most famous instructors in the sciences of Chemistry, Philosophy and Philology, so that he did not remain a stranger to these branches. In 1843 he received the degree of Doctor of Philosophy after he had published his thesis "de attractione moleculari." Together with D'ARREST, and under the direction of ENCKE, he took a zealous part in the astronomical work of the Berlin Observatory, of which his very numerous papers in the *Astronomische Nachrichten*, from the 22d volume onwards, give evidence.

In the spring of 1847 he removed to Bilk, near Düsseldorf, as director of the observatory at that place. Among the greater works produced during this time is to be mentioned the memoir on DE VICO's comet (Mémoire sur la Comète elliptique de DE VICO, Amsterdam, 1849), for which he received the gold medal of the Amsterdam Academy. It was during the time of his residence in Bilk that the text-book on Spherical Astronomy was prepared; the first edition, containing a preface by ENCKE, was published in Berlin by DÜMMLER in 1851. This text-book, continually improved and extended, reached a fourth edition, and

* Translated from the German by J. M. S.

was translated into English, Russian, Italian and Spanish. It has perhaps done more to establish the fame of BRÜNNOW than any of his other works. It soon became, and is even now, a most valuable aid to the younger astronomers to whom it offers, in its condensed form, an introduction to self study.

After the departure of Professor GALLE for Breslau, in the fall of 1851, BRÜNNOW was called to the position of first assistant in the Berlin Observatory, in which capacity he remained from November, 1851 to 1854. In Berlin he computed the tables of *Flora* with the aid of the formulae given by ENCKE in the Berliner Jahrbuch for 1857. In later years, 1859 and 1869, tables of *Victoria* and *Iris* followed, which have for a basis HANSEN'S form of the perturbative function.

His stay in Berlin was not of long duration. BRÜNNOW was tendered the office of Director of the new observatory in process of erection at Ann Arbor, Michigan, which position he accepted in 1854. In Ann Arbor he issued a journal "*Astronomical Notices*" for a number of years; it first appeared in Ann Arbor, later in Albany, whither he was called, in 1860, to infuse a new activity as Associate Director of the Observatory. In the year 1863, after the outbreak of the war, he resigned his position at Ann Arbor, whither he had returned in 1861, visited, among other places, Berlin and Hamburg, in order to assume, in 1866, as Astronomer Royal for Ireland and Professor of Astronomy in Trinity College, the charge of the Observatory at Dunsink. The results of his investigations on stellar parallax at this place are published in two volumes.

Owing to overwork and weak eyes (he would at times see lines and graduations double) he resigned this conspicuous position in order to live in Basel. In 1880 he removed to Vevey, Switzerland, and after a short stay in Oxford in 1888, he took up his residence in Heidelberg in 1889.

On the 18th of March, 1857, BRÜNNOW was married to REBECCA LLOYD, the still living daughter of Rev. HENRY PHILIP TAPPAN, at the time President of the University at Ann Arbor. The offspring of this marriage was an only son, RUDOLPH ERNST, at present professor of oriental languages in the University of Heidelberg. After the time of BRÜNNOW'S departure from Dublin, his eye-trouble prevented him from engaging deeply in scientific studies,—he limited himself to the work of issuing a new edition of his "Spherical Astronomy,"—and thus was enabled to give more time to music of which he was very fond, and for which he must have possessed a remarkable talent. It is said that once he remarked, with altogether too modest a view of his important labors in astronomy, that he should in fact have devoted himself wholly to music.

His last communication to the "*Astronomische Nachrichten*" No. 2754, is dated October 20, 1886; it refers to DE VICO'S comet.

His death was very unexpected; it is true that he suffered for a long time from weakness of the heart, and was seriously ill in June of the present year; yet as he was declared to be again convalescent he made preparations for a journey into Switzerland. A blood clot in the leg, however, again chained him to his bed and led to a painless death through apoplexy.

Although BRÜNNOW was obliged to desist from purely scientific activity during his last years he has nevertheless completed a life full of fruitful work and beauty and which will ever take a commanding place with those of his cotemporaries.*

EXPERIMENTS ON THE EFFECTIVENESS OF PHOTOGRAPHIC TELESCOPES OF DIFFERENT FOCAL-LENGTHS [BY PROFESSOR N. C. DUNÉR, DIRECTOR OF THE OBSERVATORY OF UPSALA].

In the *Vierteljahrsschrift der Astronomischen Gesellschaft*, 1891, p. 167, Professor DUNÉR gives a brief account of some experiments with photographic telescopes of different lengths, somewhat as follows. Two telescopes were ordered by him from STEINHEIL, each of 55^{mm} (2.17 inches) aperture, one being of 55^{cm} (21.7 inches) focal length, while the other was of 110^{cm} (43.4 inches). These telescopes were used simultaneously and side by side in making negatives of the *Pleiades*. The resulting star-discs were measured after separating them into two classes, (*a*) those discs where the star images were fully black, and (*b*) those where the images were not equally black throughout. Taking both classes together Professor DUNÉR finds that the shorter telescope gave stars about $\frac{2}{10}$ of a magnitude fainter

* The portrait of Professor BRÜNNOW which accompanies the foregoing notice by Professor KRUEGER was given to me by one of his former students in astronomy. It represents him as he was known to his friends and pupils in the United States, and its genial and kindly expression shows why he was as deeply loved for his character as respected and admired for his great attainments. E. S. H.

than the longer one. This shows that, in these two telescopes, the photographic brightness of the stars is proportional to

$$\sqrt[4]{f} \text{ or to } \sqrt[3]{f}.$$

The disc of a given star was larger in the longer telescope about in the proportion of 50:45.

This proportional size agrees with the result of observation when we assume that like quantities of light are spread over discs of different size—namely, that the shorter telescope gives stars $\frac{2}{10}$ of a magnitude fainter than the other. Professor DUNÉR therefore concludes that the different brightness in the two instruments depends only on the fact that the maker did not succeed in getting the star-images so small in the telescope of longer focal length and has nothing to do with the relative foci, as such. E. S. H.

ELEVATIONS AT MOUNT HAMILTON.

We are often asked for the exact elevations of points on Mount Hamilton. The following data are derived from a survey made by students of the University of California in 1887, under the direction of W. G. RAYMOND, then their Instructor in Engineering.

	Feet above Sea.
Top of the wooden cover of the reservoir *Copernicus*	4383.89
Top of the wooden cover of the reservoir *Kepler*	4256.28
Highest point of the peak *Tycho Brahe*	4214.76
Marble floor of the Lick Observatory	4209.46
Top of masonry of the reservoir *Huyghens*	4178.43
Top of masonry of the reservoir *Aquarius*	3843.99
Oak tree at *Joaquin Springs* (B. M.)	3578.65
Smith Creek (B. M.)	2146.2
Hall's Valley (B. M.)	1543.5
Summit between Hall's Valley and Grand View (B. M.)	1838.0
Grand View House (B. M.)	1500.5
Junction House (B. M.)	389.0
San José; S. P. R. R. track at station (assumed)	88.7

E. S. H.

METEOR FALL IN ARIZONA.

"TUCSON, Sept. 8, 1891.—A meteor of unusual brilliancy and size passed over Tucson at 12:25 last night. It was first seen in the southeast with a long tail of bluish-green fire. Afterward, when seen north of the city, it seemed reduced in size. The light was as brilliant as calcium when seen close to the ground, five miles northwest. It increased the temperature very perceptibly, showing 10° higher at that hour than any night during the month.

"A large stone, the weight estimated at 1000 pounds, fell fifty miles north of Tucson some weeks ago. The University of Arizona is arranging for its recovery, and it will be brought here. Large numbers of aerolites have lately been found north, and one having small diamonds in it is now on exhibition at the Smithsonian Institution at Washington, the first of the kind ever found."—Telegram to the S. F. *Bulletin*.

RAINFALL AT MOUNT HAMILTON IN THE YEARS 1880–91.

Compiled by A. J. BURNHAM.

MONTH.	1880–81	1881–82	1882–83	1883–84	1884–85	1885–86	1886–87	1887–88	1888–89	1889–90	1890–91
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
July	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00
August . . .	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.02	0.00	0.00
September .	0.00	0.10	0.00	0.65	0.65	0.15	0.00	0.33	0.49	0.00	0.80
October . .	0.00	0.33	6.16	2.15	3.71	0.05	0.60	0.09	0.03	4.38	0.02
November*	0.50	0.91	3.45	1.48	0.01	——	2.82	0.90	3.27	4.69	0.58
December .	9.68	9.72	1.93	2.05	33.84	——	2.34	11.25	4.23	13.19	5.39
January . .	3.51	3.55	3.10	5.60	1.99	——	2.83	10.04	1.04	7.93	1.38
February .	5.99	2.90	3.75	12.76	0.57	1.80	7.80	1.38	1.42	6.60	6.52
March . . .	1.13	5.40	8.66	16.35	1.15	5.77	1.39	3.40	6.17	4.39	4.26
April . . .	0.98	4.70	2.66	11.96	2.08	6.79	5.75	0.68	1.92	1.79	3.08
May	0.09	0.48	7.55	1.24	0.16	0.70	0.25	1.25	3.21	0.00	1.01
June	0.33	1.06	0.00	3.85	0.36	0.00	0.30	0.67	0.00	0.00	0.57
Sums . . .	22.21	29.15	37.26	58.09	44.67	——	24.08	30.03	21.80	42.97	23.61

NEW INSTRUMENTS FOR THE ALLEGHENY OBSERVATORY.

Through the generosity of Mrs. WILLIAM THAW, of Pittsburgh, the Allegheny Observatory is to be provided with a very powerful spectroscope to be made by Mr. BRASHEAR, and a new driving clock for the equatorial has been presented by WILLIAM THAW, jr.

For many years the late Mr. THAW stood ready to forward the researches of the Observatory by providing the delicate apparatus required by the former Director, Professor LANGLEY.

* November, 1880—One shower, amount assumed to be 0.50 inches. N. B. December, 1884. Mean Rainfall 1880–1891, 33.38 inches. Mean Rainfall at San José about 13.7 inches.

Mr. THAW's only condition was that his name should not be mentioned in connection with the gift. But all astronomers knew to whom to attribute "a gift from a friend of the Observatory."

It is eminently fitting that the THAW spectroscope and driving clock should be the first instruments acquired under the present head of the Allegheny Observatory—Professor KEELER.

E. S. H.

THE MILKY WAY IS A SEPARATE SYSTEM OF STARS.

The independent researches of Professor PICKERING at the Harvard College Observatory and of Dr. DAVID GILL, Royal Astronomer at the Cape of Good Hope, have led to the conclusion that the stars of the Milky Way form a veritable sidereal system, separate and individual. This conclusion is entirely opposed to the views which Sir WILLIAM HERSCHEL reached from his earliest observations (1785) which are still pretty generally received by those who have not given much attention to this special question. Miss CLERKE points out in the *Observatory* for September, 1891, page 302, that "the study of nebular distribution might alone, and long ago, have driven out of the field every form of 'projection-theory' of the Milky Way. For it showed the great majority of gaseous nebulæ to be embraced within its circuit, and this alone amounted to a demonstration that a physical reality, and not simply a geometrical appearance, was in question."

The best brief statement of the arguments of Professor PICKERING and of Dr. GILL is contained in a lecture by the latter delivered at the Royal Institution of Great Britain, May 29, 1891, as follows:

"I pass now to another recent result that is of great cosmical interest.

"The Cape photographic star-charting of the southern hemisphere has been already referred to. In comparing the existing eye-estimates of magnitude by Dr. GOULD with the photographic determinations of these magnitudes, both Professor KAPTEYN and myself have been greatly struck with a very considerable systematic discordance between the two. In the rich parts of the sky, that is in the Milky Way, the stars are systematically photographically brighter by comparison with the eye observations than they are in the poorer part of the sky, and that not by any doubtful amount but by half or three-fourths of a magnitude. One of two things was certain, either that the eye observations were wrong, or that the stars of the Milky Way are bluer or whiter than other stars. But Professor PICKERING, of Cambridge, America, has lately made a complete photographic review of the heavens, and by placing a prism in front of the telescope he has made pictures of the whole sky like this. (Here two examples of the plates of Pickering's Spectroscopic *Durchmusterung* were exhibited on the screen.) He has discussed the various types of the spectra of the brighter stars, as thus revealed, according to their distribution in the sky. He finds thus that the stars of the *Sirius* type occur chiefly in the Milky Way, whilst stars of other types are fairly divided over the sky.

"Now stars of the *Sirius* type are very white stars, very rich relative to other stars in the rays which act most strongly on a photographic plate. Here then is the explanation of the results of our photographic star-charting, and of the discordance between the photographic and visual magnitudes in the Milky Way.

"The results of the Cape charting further show that it is not alone to the brighter stars that this discordance extends, but it extends also, though in a rather less degree, to the fainter stars of the Milky Way. Therefore we may come to the very remarkable conclusion that the Milky Way is a thing apart; and that it has been developed perhaps in a different manner, or more probably at a different and probably later epoch from the rest of the sidereal universe."

DR. RUTHERFURD'S NEGATIVES OF THE MOON, ETC.

In 1884 Dr. RUTHERFURD presented to the Observatory of Columbia College his 13-inch equatorial (with its photographic corrector) as well as other important instruments belonging to his private observatory. Subsequently he gave his famous collection of original negatives taken in the years 1858–1877 to the same institution.*

Professor REES has been kind enough to have positive copies on glass made from the best of these negatives and they have been presented by Columbia College to the Lick Observatory, where they will be of the highest value for comparison with other photographs. A collection of the best original negatives of the moon taken at Mount Hamilton, has also been deposited at Columbia College. A list of the negatives of Dr. RUTHERFURD

* A complete list of these is given in the *Annals* of the New York Academy of Sciences (1891) by Professor J. K. REES, Director of the Columbia College Observatory.

now in the Lick Observatory collection follows. Mrs. ANNA PALMER DRAPER has also signified her intention of presenting to us a set of copies of negatives of the moon taken by the late Dr. HENRY DRAPER.

For each of these most welcome gifts the cordial thanks of the Lick Observatory are returned. E. S. H.

LIST OF THE MOON-NEGATIVES MADE BY DR. LEWIS M. RUTHERFURD AND PRESENTED TO THE LICK OBSERVATORY BY COLUMBIA COLLEGE.

DATE OF THE NEGATIVE.	MOON'S AGE (approximate).	REMARKS.
1859, March 9:	5 days	.....
1859, March 10:	6 "	.....
1864, December 4:	6 "	.....
1862, January 7:	7 "	....Enlarged about two diameters.
1865, February 2:	7 "	.....
1870, April 8:	7 "	....In duplicate.
1862, April 6:	7 "	....Enlarged about two diameters.
1870, April 9:	8 "	....In duplicate.
1865, March 6:	9 "	....Enlarged about two diameters.
1862, March 9:	9 "	....Enlarged about two diameters.
1870, July 8:	10 "	....In duplicate.
1870, August 7:	10 "	....In duplicate.
1865, January 8:	11 "	.....
1865, February 6:	11 "	...Enlarged about two diameters.
1870, April 12:	11 "	....In duplicate.
1870, July 10:	12 "	....In duplicate.
1865, January 11:	14 "	.....
1870, May 14:	15 "	.....
1865, January 12:	15 "	....Enlarged about two diameters.
1864, November 14:	16 "	.....
1870, March 18:	16 "	.....
1870, August 13:	16 "	....In duplicate.
1870, August 14:	17 "	....In duplicate.
1870, September 13:	18 "	....In duplicate.
1870, September 14:	19 "	....In duplicate.
1870, September 15:	20 "	....In duplicate.
1870, August 17:	20 "	....In duplicate.
1870, August 19:	22 "	....In duplicate.
1870, August 20:	23 "	....In duplicate.
1870, September 19:	24 "	....In duplicate.

Diagram of the Cluster in Hercules.

Characteristic Forms Within the Cluster in *Hercules*.

During 1890 and 1891 the cluster in *Hercules* was photographed with the Great Telescope, by Professor Campbell and myself, as follows:

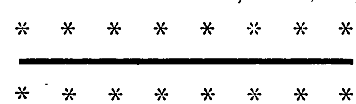
1890, June 8,	exposed	60^m;	1890, August 4,	exposed	17^m;
June 9,	"	120^m;	1891, July 28,	"	122^m;
June 11,	"	138^m;	August 25,	"	170^m.
August 3,	"	58^m;			

The best negative is that of July 28. Glass copies of it have been sent to various observatories, etc., and have been exhibited to the Astronomical Society of the Pacific.

The accompanying cut gives a diagram (only) from one of the negatives and is intended, not as a picture, but simply to shorten the verbal explanations.

In the first place let us define a dark channel or lane to be a space of considerable length, empty of stars, and bordered at least on one side by a row of stars, thus

It is usually bordered on both sides by stars, thus



In the accompanying cut the reader will note sundry dots which were inserted on the original negative before printing. They are easily distinguished from the stars of the cluster, and serve to mark certain positions, approximately. At each one of these dots at least *two* dark channels meet (and usually *three* such) which make with each other angles of about 120° (sometimes a little more; sometimes a little less). No or few other prominent channels can be found which meet at angles different from 120° ±. There are *thirteen* such dots or intersections on the plate, *one* of which corresponds to the intersection of the dark channels discovered by Lord Rosse. They may be considered as centres of force.

An inspection of the original negative shows that if the exposures could have been prolonged to 3½ or 4 hours, other dark lanes, which faintly show in our present negatives, would have become plain, and it also seems to show that these new dark lanes (bordered by stars which are very faint in our present negatives) meet at the angle of 120°±. The *thirteen* intersections here marked make it plain that the forces which have formed this particular cluster are such as to produce this type-form, and to make it characteristic of the cluster in *Hercules*. It is also (probably) characteristic of the Trifid Nebula (G. C. 4355) in which at least two such intersections can be located. The symmetry of the arrangement of the thirteen dots is, to say the least, note-worthy.

It is not intended to say that the systems of dark channels are the most immediate and direct result of the forces which have formed the cluster; they may be but the consequences of the intersection of other and simpler forms; but it is intended to point them out as the forms which can most readily be detected and verified, and as truly characteristic.

Visual observations on Sept. 27 by Professor CAMPBELL and myself confirm the results from the negatives, and I have found a number of the channels in a beautiful negative of the cluster taken by ISAAC ROBERTS, esq., at Crowboro', and kindly presented by him to the Lick Observatory.

In *Himmel und Erde* for 1889, page 503, I pointed out that an examination of the more prominent planetary nebulæ showed the prevalence of a certain limited number of type-forms, according to which the nebulosities seemed to be arranged.

In the *Monthly Notices* of the Royal Astronomical Society volume 48, page 388, Professor SCHAEBERLE and myself spoke of the discovery of a helix-nebula (G. C. 4373). In the *Publications* of the A. S. P., vol. I, page 25, I showed that essentially all the "spiral" nebulæ might be formed by the projection of a certain type-helix whose form was given. It seems to follow also that the cluster in *Hercules* is formed by forces which have impressed upon it (at least) one characteristic type-form; and that this form recurs no less than thirteen times in our negatives of two hours exposure. The proof of this is to be derived from an examination of the negatives themselves. I regret that it is not practicable to give a perfect reproduction of them here. The accompanying cut will, however, locate the intersections of which I have spoken, and their verification may be obtained from the original negatives now at the Lick Observatory, or from better ones which will be taken here and elsewhere.

E. S. H.

GIFT TO THE LICK OBSERVATORY FOR THE PUBLICATION OF THE DRAWINGS OF THE MOON ENLARGED by PROF. WEINEK FROM NEGATIVES MADE AT THE LICK OBSERVATORY.

WALTER W. LAW, esq., of Yonkers, N. Y., has offered to the Lick Observatory the sum of one thousand dollars to defray the cost of reproducing the drawings of the Moon enlarged by Prof. WEINEK from original negatives made at Mount Hamilton (See *Publications* A. S. P., vol. III, page 333.) This generous gift will enable us to devote a separate volume to the Moon and to illustrate it in a splendid manner. E. S. H.

"PROPOSED DISSOLUTION OF A FAMOUS FIRM.

"BOSTON, October 18.—The noted telescope-makers, ALVAN G. and GEORGE B. CLARK, Cambridge, are to dissolve partnership. This step is taken for the sole reason that GEORGE B., the senior member, is physically unable to continue in active business and desires to be relieved of all responsibility. Mr. CLARK senior is 65 years old, and while he cannot be strictly called a sick man is far from being strong. He went into business when he was 20." —S. F. *Chronicle*, October 19, 1891.

THE GREAT RED SPOT ON *JUPITER* [BY W. F. DENNING, F. R. A. S].

"The great red spot has been visible, and its appearance and movements closely watched during thirteen years, for it was in July, 1878, that it was first announced as a striking object. But it probably existed long before this, for the drawings of previous observers include forms which have a very suggestive resemblance to the red spot, though they are under a less conspicuous aspect. There is, in fact, little doubt that this marking is an old feature, but it is liable to considerable variations of tint, inducing obvious changes in its general appearance as presented to telescopic observers. Layers of cloud, moving with unequal velocities and at different elevations above the surface of the planet, probably overlap the spot and partially obliterate it at times, but its definite elliptical outline has always been preserved, and its dimensions have not varied materially. It is the coloring of the spot that has exhibited inconstancy, and especially that of the central region, which changed from brick-red in 1878–81 to a very light tint, differing little, if at all, from the other parts of the planet's disc in the same latitude. But the margin of the spot has been more durable, and it was visible for several years as a pink ellipse, offering a great similarity to the ellipse seen by GLEDHILL in 1869–70.

"After a somewhat precarious existence, the spot appears to be recovering prominence, though its present aspect will not bear comparison with the features it presented about twelve years ago. Still it is now a fairly conspicuous marking, with a depth of tint far more pronounced than in the years 1884–85. The central part of the spot appears to have regained the reddish hue, and the general appearance of the object is sufficiently marked to recall the grand views it afforded at the period of its best display."—From *Nature*, September 3, 1891.

ELEMENTS AND EPHEMERIS OF COMET *e* 1891 (BARNARD, OCTOBER 2). BY W. W. CAMPBELL.

From the three observed places of this comet given below, kindly furnished by Mr. BARNARD, the elements and ephemeris were computed and distributed by telegraph to the other observatories.

	Greenwich m. t.	App. α	App. δ
1891 Oct. 3	1^h 1^m 10^s	7^h 31^m $25^s.25$	$-27°$ $52'$ $18''.6$
4	0 14 24	7 37 0.86	−29 17 3.5
5	0 8 9	7 42 54.03	−30 43 44.7

Elements.

$T =$ Gr. m. t. 1891 Nov. $8^d.7543$.

$$\left.\begin{aligned} \omega &= 262° \;\; 6'.26 \\ \Omega &= 215° \;\; 38'.42 \\ i &= 75° \;\; 50'.15 \end{aligned}\right\} 1891.0.$$

$\log q = 0.00716$.

Residuals for the middle place (Obs.—Com.):

$\cos \beta' . \Delta\lambda' = -0'.02, \qquad \Delta\beta' = -0'.04.$

Ephemeris.

Gr. m. t.		α	δ	Brightness.
1891 Oct.	6.5	7^h 52^m 1^s	$-32°$ $52'$	1.05
	10.5	8 18 0	−38 18	
	14.5	8 46 20	−43 8	
	18.5	9 16 45	−47 14	1.05

THE LADD OBSERVATORY (PROVIDENCE, R. I.).

The LADD Observatory, founded by His Excellency HERBERT WARREN LADD, Governor of Rhode Island, was formally presented to BROWN University October 21, 1891. Professor WINSLOW UPTON is the Director.

Scientific Visitors to the Lick Observatory.

Professor SWAIN, Professor of Mathematics and Astronomy in the Stanford University, spent the second week of September at Mount Hamilton in a study of the general work of the Observatory and in practice with some of the instruments. E. S. H.

Comparative Brevity of the English, French and German Languages in Scientific Writings.

The new (and very welcome) publication "International Meteorological Tables" (Paris, 1890), contains an introduction three times repeated; first, in the French, second, in the English, and third, in the German language. It is interesting to note that the same matter expressed in French requires a trifle less than 65 pages; expressed in English, a trifle less than 66 pages and, expressed in German, a trifle more than 71 pages. E. S. H.

Errata in Publication No. 17 (by Professor Michelson).

Page 275, last line; should read "fringes should be of equal width."
Page 275, fig. 4; the numbers denoting abscissæ should be halved.
Page 276, line 16; it should read "$\frac{a}{a_0} = 1.22$, whence, putting s"
Page 278, line 5; omit "the differences between."

Erratum to Publication No. 17.

In the last line of page 296, the quantity within the brackets [ ] should be squared. J. M. S.

Additional Corrections to Watson's Theoretical Astronomy.

My attention has been called to the first two of the following errata by Professor WEINEK, of Prague, and to the third one by Mr. W. J. HUSSEY, of the Detroit Observatory, Ann Arbor.

Page	Line	*For*	*Read*
172	− 6	second	fourth
173	− 6	(14)	(11)
649	+ 8	Circumference of a circle when $r = 1$	Semicircumference of a circle when $r = 1$
30	+ 13	equation.	equation

These are additional to the lists published in the *Publ.* A. S. P., vol. III, pp. 87, 223. Several errata which appear in the original edition are corrected in the later editions. W. W. C.

UNUSUAL PHENOMENON OBSERVED ON *JUPITER*, SEPT. 29, 1891, BY HENRY S. HURLBERT.

[Extract from a letter dated Detroit, Michigan.]

"* * * On the evening of September 29, 1891 at 7:02 P. M. Central Standard Time, I noticed the following interesting phenomenon on *Jupiter*. Satellite I was in transit, showing a well-defined white disk against the darker background of the southern equatorial belt. Following this was the customary shadow, and following this at an *equal* distance was a second shadow. This secondary shadow was a trifle smaller and considerably fainter than the true shadow and seemed to be surrounded by a faint penumbra. This secondary shadow disappeared simultaneously with the *egress* of the true shadow. * * * The seeing was exceptionally good and the air very steady. My instrument is a three-inch [refractor] by BRASHEAR mounted equatorially with clock, etc., and powers of 126, 160 and 212 diameters. * * * "

[The above letter was accompanied by a detailed drawing.]

Minutes of a Special Meeting of the Directors held in the Rooms of the Society, Nov. 16, at 3.30 P. M.

President Pierson presided. A quorum was present.

On motion, the life-membership fee of Ex-Gov. R. H. Waterman, deceased, was ordered transferred to the General Fund.

On motion, the Secretary was instructed to notify all members in arrears for dues, that unless payment is made before December 15th, next, their membership will be forfeited.

The meeting then adjourned.

Minutes of a Meeting of the Board of Directors held in the Society's Rooms, Nov. 28, 1891.

President Pierson presided. A quorum was present. The minutes of the last meeting were read and approved.

The following members were duly elected:

List of Members elected November 28, 1891.

Miss E. M. Bardwell	The Observatory, South Hadley, Mass.
Henry Berger	Observatory Hill, Allegheny, Pa.
Dr. Henry Crew	Mount Hamilton, Cal.
George W. Hewitt	Burlington, N. J.
John L. Howard	132 Market Street, S. F., Cal.
Prof. C. H. Howieson	Chippewa Falls, Wisconsin.
Henry A. Keller	San Bernardino, Cal.
Walter W. Law	Yonkers, N. Y.
John McDonough	193 28th Street, Brooklyn, N. Y.
Hon. E. S. Martin	Box 75, Wilmington, N. C.
C. A. Murdock	532 Clay Street, S. F., Cal.
Miss M. A. Orr	Maclean, Clarence River, N. S. W.
M. M. O'Shaughnessy	2010 Eddy Street, S. F., Cal.
Mrs. G. J. Roote	Mansfield, Wright Co., Missouri.
Edward Perrouet Sells	The Observatory, Adelaide, South Australia.

A number of candidates were proposed for the January meeting.

The resignations of several members were received and accepted.

The Treasurer presented his bi-monthly report which was received and filed.

The following rules governing the distribution of extra copies of the *Publications*, of reprints, etc., to contributors were adopted.

I. Each person who contributes an article of at least one page in length to any number of the *Publications* is entitled to five copies of the complete number which contains his article. These copies will be sent to him without any application on his part.

II. Should any author desire more than five copies of a complete number containing his article he can obtain them by purchase from the Secretary at the fixed rate of twenty-five cents per number, *provided* that a sufficient quantity of this particular number is in store.

III. Complete volumes for past years will be supplied to members (only), so far as the stock in hand is sufficient, on the payment of two dollars per volume to either the of Secretaries. Booksellers may purchase complete volumes for past years at the rate of five dollars per volume, and of current years at the rate of six dollars.

IV. Should an author desire fifty or more separate *reprints* of his article he can obtain them by addressing a written request to that effect to either of the Secretaries at the same time that his *MS.* is forwarded. All such reprints will be bound uniformly in paper covers, with the paging of the *Publications* unchanged, and must be paid for by the author at the following fixed charges (which can be remitted by postal notes or American postage stamps).

50 copies of 1, 2, 3, 4 or 5 pages	$3 00
50 copies of 6, 7, 8, 9 or 10 pages	4 00
100 copies of 1, 2, 3, 4 or 5 pages	5 00
100 copies of 6, 7, 8, 9 or 10 pages	6 00
200 copies of 1, 2, 3, 4 or 5 pages	7 00
200 copies of 6, 7, 8, 9 or 10 pages	8 00

No order for reprints can be filled for less than 50 copies. It is requested that authors desiring extras, reprints, etc., will be prompt in making their desires known.

The meeting then adjourned.

Minutes of a Meeting of the Astronomical Society of the Pacific, held in the Lecture-Hall of the California Academy of Sciences, Nov. 28, 1891.

The minutes of the last meeting were approved.

A list of presents was read and the thanks of the Society were voted to the givers.

The thanks of the Society were returned to the California Academy of Sciences for the use of their lecture-hall.

The list of new members elected at the Directors meeting was read to the meeting.

The following papers were presented:

1. The Lunar Crater *Archimedes*, by Professor L. WEINEK, Director of the Observatory of Prague.
2. Review of the Parallax Determinations made by Dr. KAPTEYN, with the Leyden Meridian Circle, by Professor L. BOSS, Director of the Dudley Observatory.
3. Observations of a Dark Transit of *Jupiter's* Satellite III, by JOHN TEBBUTT, F. R. A. S., Windsor, N. S. W.
4. The Forms of *Jupiter's* Satellites, by Professors SCHAEBERLE and CAMPBELL, of the Lick Observatory.
5. The Rotation Period of *Jupiter's* III Satellite, by the same.
6. Path of a Shooting Star, by T. KÖHL, Odder, Denmark.

A photograph of a drawing of the lunar crater *Petavius* made by Professor WEINEK, from Lick Observatory negatives, on a scale of more than 100 inches to the Moon's diameter was exhibited to the meeting. The diameter of the crater itself is about six inches. The drawing represents more than 150 hours of actual work.

Adjourned.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend any or all of the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific," at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

[illegible]